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Realigning Contract Incentives for the Non-Competitive Environment of the US Shipbuilding Industry

by

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Abstract

It is suspected that the lack of commercial shipbuilding available in the US resulting in the consolidation of the US shipbuilding industry as a whole limits the negotiating capacity for the US Navy and promotes suboptimal contracts that continuously produce major cost and production time overruns. Several incentives and contracting strategies are explored to better incentivize, through formal and informal means, the best value for the Navy in the production of large ships.

These methods mainly include a sharper focus within the contracts on the scale and alignment of incentives. Some incentives in use in current contracts were found to be counterproductive to the goals of reduced cost, timeliness, and quality because of the disproportionate scaling of one goal's incentive over the others. Once the shareline incentive is lost as in the LPD 17 program, there is much less of a need for the shipbuilder to control costs. Also, a redirection of resources spent on smaller incentives in order to increase larger incentives such as larger order quantities is suggested.

These improvements, however, might only lead to a marginal effect in contract efficiency at best. In order to produce a larger effect, the competitive base in the shipbuilding industry must be increased. This increase in the competitive base is possible through a large capital investment into an existing tier 2 shipyard in order to increase its production capabilities to the level of a tier 1 shipyard.

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A special thanks goes out to the members of the MIT 2N program without whose help I would never have been able to achieve this degree.

List of Acronyms

ASN	Assistant Secretary of the Navy
CBO	Congressional Budget Office
CEO	Chief Executive Office
CPAF	Cost Plus Award Fee
CRS	Congressional Research Services
DASN	Deputy Assistant Secretary of the Navy
DDG	Destroy, Guided Missile
FAR	Federal Acquisition Regulations
FPI	Fixed Price Incentive
FY	Fiscal Year
GAO	General Accounting Office
GD	General Dynamics
HII	Huntington Ingalls Industries
IQT	In-Q-Tel
LCS	Littoral Combat Ship
LPD	Landing Platform Dock (Amphibious Transport Dock)
MIT	Massachusetts Institute of Technology
NSRP	National Shipbuilding Research Program
PEO	Program Executive Office
PIE	Production in the Innovation Economy
RMO	Repair, Maintenance, and Overhaul
ROI	Return on Investment
RD&A	Resarch, Development, Acquisition
SEC	Security Exchange Commission
SIBIF	Shipbuilding Industrial Base Investment Fund
US	United States
USD	United States Dollar
VCS	Virginia Class Submarine
WWII	World War 2

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Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction and Overview

This thesis looks at current contract incentives written into shipbuilding contracts in order to identify and better align incentives between the shipbuilding industry and the US Navy. An alignment of these incentives is meant to produce a reduction in cost of ships for the Navy while maintaining a required level of quality and timeliness in the production of those ships and long-term production capabilities at commercially owned shipyards. The incentives are classified as either relational contracts (i.e. informal agreements sustained by the shadow of the future[1]) or formal contracts (i.e. the kind that can be enforced by courts or some observing third party). Those contracts are viewed through the lens of lessons learned from both principal-agent and game theory models. This lens is applied in hopes of discerning additional and potentially innovative methods for applying incentive structures in shipbuilding contracts.

Four recent (within the last 20 years) Naval construction contracts are identified for examination and analysis: Littoral Combat Ship, LPD-17, Virginia Class Submarine, and DDG 1000. The degree of success of these contracts can be judged based on their ability not to exceed a 15% increase over initial estimated cost, a timely delivery component, and overall quality of the end product.

These contracts provide examples of two seemingly different contract structures used consistently and canonically in current shipbuilding contracts. The overall contract structures used are Fixed Price Incentive (FPI) and Cost Plus Award Fee (CPAF). Though there are only two high level types of contract structures, each contract type has substantial design freedom by implementing different incentive allocations that create additional complexities to be analyzed in particular situations. Those incentive allocations might show ostensibly across a spectrum of specific transactions such as pay for performance or time dependent structures and provisions for initial and subsequent contract awards.

[1] Gibbons, R., Henderson, R. “Relational Contracts and Organizational Capabilities”, Articles in

The shipbuilding industry is an imperfect market where free market competition is not the main driver of performance. The market is characterized by a combination on monopsony[2] (only a single buyer) and oligopoly[3] (only few sellers). In a monopsony situation, the buyer usually maintains all of the power to adjust prices since the seller has no alternative with whom to trade. The oligopoly is an opposite balance of power. The shipbuilding industry couples the two lending itself to the analysis of its intrinsic motivators and equilibrium. The stakeholders have to be clearly outlined and their baseline motivations established. Once those motivations are established, then the effects of incentives on those motivations and subsequent outcomes can be analyzed to map an incentive to a particular outcome. There are times in which an incentive is applied to affect a particular outcome, but has either a directly opposite effect or produces an entirely different outcome. Kerr discusses how this situation can occur in several industries where a company is rewarded for completely different criteria than the outcome hoped for by the government. For instance, he discusses a situation in which a company might have a 10 percent chance of being fined a million dollars and have to pay for equipment if caught polluting a river or pay 11 million dollars for the equipment. The company has more incentive to game the system in hopes of not being caught than paying the extra money outright. This misalignment is coupled with the probability that the CEO is incentivized by the stockholders to maximize profit.[4]

Beyond just an alignment of incentives through contract structure, in such an imperfect market, there might also be an opportunity for more than just a base cooperation to create a single entity that might be more beneficial to the whole rather than just the sum of its parts. This would be the ultimate form of incentive alignment: full alignment of interests through complete integration. Even some

[2] http://www.economicsonline.co.uk/Business_economics/Monopsony.html. Accessed May 2013
[3] http://www.economicsonline.co.uk/Business_economics/Oligopoly.html. Accessed May 2013
[4] Kerr, Steven, "On the Folly of Rewarding A, While Hoping for B", The Academy of Management Journal, Vol. 18, No. 4 (Dec., 1975). pp. 769-783.

partial integration between the shipyards and the Navy could potentially change the entire marketplace and produce a more favorable environment for the Navy and subsequently the US government. The integration of the Navy with the shipyards would involve some level of nationalization of the shipbuilding industry or more fully involved investment from the Navy to include some form of equity sharing.

1.1 Current Industrial Environment

In the US, the shipbuilding industry consists of both tier 1 and tier 2 shipbuilders. The tier 1 shipbuilders are primarily focused on the design and construction of large complex Navy vessels. These vessels include aircraft carriers, submarines, frigates, destroyers, and amphibious landing vessels. There are currently only two tier 1 shipbuilders; Huntington Ingalls Industries (HII) and General Dynamics (GD). The tier 2 shipbuilders are more diverse and take on the construction of smaller Navy ship projects such as patrol craft and Coast Guard cutters including other small commercial craft and offshore oil rigs.

This is in large contrast to ship production during WWII. During WWII, there was a shipbuilding program that led to the production of 5,500 vessels of which 2,710 were the 14,000 ton liberty ships produced by new shipyards in the US. By 1943, there were three liberty ships being constructed per day. There were so many ships being produced in the US that new yards had to be established across the US to meet the demand.[5]

Currently, the bulk of the large commercial shipbuilding projects are dominated by foreign shipbuilders due mostly to smaller margins and a larger competitive base. However, tier 2 shipbuilders might be competitive with foreign companies in certain instances where they have a particular expertise.

[5] Hickman, Kennedy, "World War II: The Liberty Ship Program", About.com, accessed May 2013. http://militaryhistory.about.com/od/industrialmobilization/p/libertyships.htm

According to a recent report on the shipbuilding industry conducted by the Industrial College of the Armed Forces and recent SEC filings, the two publicly traded tier 1 shipbuilders each held approximately 35% of the total $19B USD shipbuilding revenues in 2011. [6]

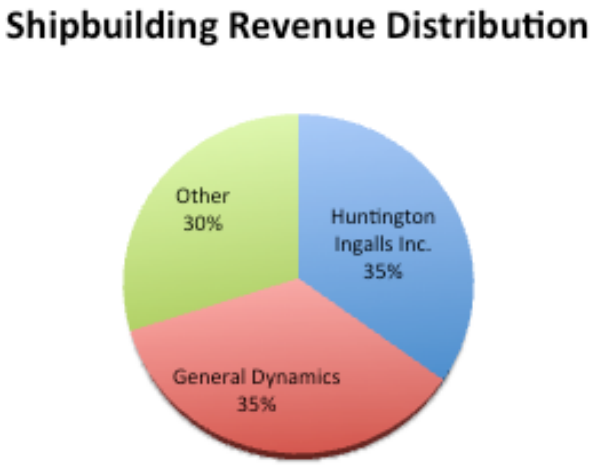

Figure 1 Shipbuilding Revenue Distribution

GD revenues are compromised of 70% US government sales which owe approximately 80% to large Navy ship sales including combat systems and information technology. HII revenues are almost 100% owed to US government sales for large ship construction due to its spin off from Northrup Grumman as a dedicated entity for naval ship construction. Repair, maintenance and overhaul (RMO) of U.S. ships is conducted both at private and public (for nuclear powered submarines) shipyards and is included in Figure 1.

The structure and size of the shipbuilding industry in the US relies heavily on government support through large contracts for acquisition and maintenance. Commercial and foreign military sales are almost non-existent in the shipbuilding market for US-based companies. The market size is small for US shipbuilders

[6] Final Report, Shipbuilding Industry. The industrial College of the Armed Forces. Spring 2011.

because of competitive advantages of foreign countries, such as lower wages, less strict labor policies, and increased automation. Reduced cost structures as shipyard management is improved generally allow foreign companies to provide lower pricing than their US competitors. However, due to the strategic importance of shipbuilding to maintaining US military capabilities and self-reliance this industry has been protected from offshoring in contrast to other manufacturing industries[7]. The small market size combined with the capital intensive nature of the shipbuilding industry makes it less attractive for new entrants, including tier 2 shipbuilders that might consider a jump to the tier 1 segment.

These competitive advantages of foreign companies create high barriers to entry that limit the commercial segment of the US shipbuilding industry. Because there is such a limited market for large ship construction only a small number of US companies maintain the capability (both staff and infrastructure) to perform large ship construction. The required industrial base for military construction is only kept alive by artificial means, such as the US code 10 section 7309 and code 14 section 665 - which prohibit the construction of armed forces and US Coast Guard vessels in foreign shipyards - along with US code 10 section 7310 - which restricts the overhaul and repair of those vessels in foreign shipyards[8]. These codes along with the Jones Act - which maintains that vessels operating domestically must be constructed, repaired, and serviced in US shipyards - limit the availability of contracted ship construction from foreign shipbuilders[9]. While these regulations may limit the competitiveness of pricing for new ship construction, the current doctrine is that they are necessary to maintain a level of shipbuilding capability and capacity amongst US companies. This industrial base is required to provide adequate supply of high-quality ships in order for the Navy to maintain national security and defense.

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[7] Berger S. with the MIT Task Force on Production in the Innovation Economy, "Making in America – From Innovation to Market", MIT Press, September 2013
[8] All US Codes could be searched on http://law.onecle.com/uscode/
[9] http://www.americanshippingco.com/section.cfm?path=326,346

The limited market for large ship construction inhibits the entrance of additional competitors for naval construction contracts beyond the two majority revenue earners GD and HII. The small competitive base for large ship construction then puts the Navy at a disadvantage when negotiating those contracts. If incentives are not aligned well enough between the Navy and its contractors, the result can be a very expensive and/or a poorly executed contract. The question then becomes, how do we align those incentives between the Navy and its contractors in order to improve the cost/performance ratio of shipbuilding contracts? This is the central question of this research.

1.2 Thesis Structure

Chapter two summarizes important information obtained through the literature review. The literature review is focused primarily on the work done by Professor Robert Gibbons in the analysis of principal agent theory and game theory models as methods to explain behavior by market participants.

The principal agent theory is reviewed initially in order to establish a basis for discussion. The game theory models then build on that theory by providing analysis of less straightforward situations where the outcome is based on additional factors beyond bonus size and a direct mapping from effort to outcome. The focus for both is on the lessons that both theories provide and how those lessons might eventually relate to contract synthesis and analysis.

Chapter three discusses the research methodology. Interviews will be discussed as far as they relate to development of the motivations for both sides of a shipbuilding contract.

Chapter four discusses findings from both the interviews and the literature review on the identification and motivations of each of the stakeholders.

Chapter five will discuss each of the contract types. The initial environment during the acquisition of the ship as well as the overall contract structure will be discussed leading into the main incentive structure points of the contract. Those incentive structure points will then be analyzed for their potential outcomes, both positive and negative, based on the underlying motivations of each agency.

Chapter six will examine four contract case studies (Littoral Combat Ship, LPD-17, Virginia Class Submarine, and DDG 1000) for their similar points as well as point out where each of the programs may or may not have been successful in the end result. Potential fixes for similar issues identified across multiple contracts as well as those that are uniquely applicable will be proposed.

Chapter seven will discuss the potential for a union of the Navy with the shipbuilding industry. This union will be discussed both as a full nationalization of the shipbuilding industry and as a partial entrance as an additional major competitor by the Navy itself to increase the competitive base and push the market more closely toward its free market realization.

Chapter eight summarizes the conclusions gained from the contract incentive analysis as well as the increase in competitive base and articulates the recommendations of the thesis.

This thesis could potentially be used by contracting officers and program managers to form a basis for identifying and analyzing incentive structures within ongoing and future contracts.

Chapter 2: Literature Review

A literature review was conducted in order to develop a set of analysis tools with which to discuss the contracts that were analyzed and the interviews that were conducted. The literature review is focused primarily on the work of Gibbons in the analysis of principal agent theory and game theory as a starting point for discussion of incentive structure though there is substantial additional research into incentive structures especially in relation to compensation.[10]

The next step reviewed some of the other industry practices and In-Q-Tel as case studies for what the potential structure of a different role for the Navy in shipbuilding could potentially look like.

2.1 Principal Agent Theory

The principal agent theory provides a starting point for the discussion of each of the contracts. At its most basic point, the interaction between the Navy and the shipbuilders is a principal agent scenario where the Navy is the principal and the shipbuilder the agent.[11]

A summation of this theory as a pay for performance model gives the Navy's value created by the actions of the shipbuilder in the following formula:

$$y = a + \varepsilon$$

y – Navy's value created by the actions of the shipbuilder

[10] For example, Fahlenbrach and Stulz (2009) investigate the effects of bank CEO incentives on the 2008 credit crisis, Borenstein, Busse, and Kellog (2007) how incentive schemes may induce inefficient behavior through a discussion of natural gas procurement by regulated public entities, and Jensen and Meckling (1976) use Agency theory to discuss capital structure and associated agency costs and resulting managerial behavior.

[11] Gibbons, R. "Lecture Note 1: Agency Theory", MBA Course 15.903 Organizational Economics and Corporate Strategy, http://web.mit.edu/rgibbons/www/. Accessed April 2013.

a – action taken by the agent

ε – noise factor beyond the agent's control

In this situation, a ship's quality, timely delivery, and cost are the direct measures of the Navy's value, though larger benefits to the Navy such as the value of maintaining surge capacity are more difficult to capture. The actions taken by the agents as shipbuilders are ultimately the actions that result in the creation of that value such as expediting their delivery or increasing quality control. The noise factors are things out of the shipbuilder's control like Hurricane Katrina.[12] For simplicity, we will ignore the noise term.

The shipbuilder receives a wage that is based on a salary or profit margin and a bonus rate that reflects some percentage of the value that is being created by the shipbuilder's actions so that:

$$w = s + b * y$$

w – shipbuilder's wage based on a salary or profit

s – salary or profit

y – Navy's value created by the actions of the shipbuilder

b – bonus rate

The payoff for the shipbuilder comes from the difference between the wage at a particular level of effort and the cost associated with creating that value for the Navy, creating a utility function for the shipbuilder.

$$u = w - c(a)$$

u – utility function

w - shipbuilder's wage based on a salary or profit

[12] IBID.

c(a) – shipbuilder's cost associated with creating value for the Navy

The payoff that the Navy receives is the difference between the value that they receive from the shipbuilder and the wage that they pay the shipbuilder:

$$\pi = y - w$$

π – payoff the Navy receives
y – Navy's value created by the actions of the shipbuilder
w – shipbuilder's wage based on a salary or profit

It can then be said that a larger bonus rate *b* or in this case any incentive will increase the payoff for shipbuilder and strengthen the incentive effect from the perspective of the shipbuilder. However, there is some inherent risk for the shipbuilder where the cost associated with creating a certain value for the Navy *c(a)* while trying to maximize the wage *w* is larger than the perceived value from the Navy's perspective. The risk is larger for the shipbuilder if the incentive is more heavily based on the perceived value for the Navy. In this case, the potential risk to the shipbuilder is more than the additional payoff that the shipbuilder will see from an increase in bonus.

The literature goes further to describe what is referred to as a "multi-task" agency problem or a "get what you pay for" case. Here the value created for the Navy is replaced by a performance metric. The payoff for the shipbuilder then becomes:

$$u = s + b * p - c(a)$$

u – utility function
s – salary or profit
b – bonus rate
p – performance metric

c(a) – cost associated with creating value for the Navy

In this case if:

$$y = a(1) + a(2)$$

and

p = a(1)

then value for a(2) is lost. In the Navy's case, since their value is defined by the timely delivery of the ship, the quality of the ship, and a low cost, if the bonus rate is paid based only on the timely delivery , then only timely delivery is really incentivized. There is no reason for the shipbuilder to pursue quality or lower cost since they are not getting paid for those things.

The following numerical example will further clarify these relationships.

Suppose:
a(1) = *a*(2) = 1
s = 100
b = 100
c(a) = 10

Since:
p = a(1) = 1

Therefore:
*u = s + b*p – c(a)* = 100 + 100*1 – 10 = 190

Whereas, if:
p = y = a(1) + a(2) = 2

Then:

$u = 100 + 100*2 – 10 = 290$

If the performance metric *p* used to assess the total utility payoff to the shipbuilder does not include the full value the Navy is searching for, then the utility payoff is less for the shipbuilder and the shipbuilder is less incentivized to perform as well.

The principal agent theory as described in this literature gives four main lessons[13]:

1. Stronger bonus rate provides stronger incentives.
2. Stronger bonus rate comes with additional risk.
3. It's difficult to create the right incentives based on objective performance metrics.
4. Efficient bonus rates depend on scale and alignment.

The stronger bonus rate would obviously provide a stronger incentive. If the shipbuilder is receiving a larger percentage of the value that it is creating for the Navy, then the shipbuilder is more incentivized to produce a larger value for the Navy. With that stronger bonus rate, however, there is also a level of associated risk. There is additional cost that is associated with creating additional value for the Navy and as the potentially created value increases so does the marginal cost for achieving that added value.

For instance, if the shipbuilder's bonus rate for reduced cost of the ship were very high then the shipbuilder might be moved to make a large investment on their cost reduction efforts such as Electric Boat did in the Virginia Class Submarine program when investing in outside consultants to improve their cost structure. The investment required to reduce costs by a small amount would be

[13] IBID.

less as it would only involve internal consultants, but to reach a larger reduction, external consultants were required and the investment was much more. If the Navy did not perceive the added value or the cost reduction was not large enough by the Navy's standards, then Electric Boat would have made a large self-investment and incurred a large cost without any additional payoff.

The issue of risk associated with a higher bonus rate for a performance metric is also present for the Navy. From the Navy's perspective, however, the risk comes out of incentivizing the wrong action associated with the performance metric *p*. One instance of a misaligned incentive came from a discussion on the cost performance index incentives. The cost performance index is a measure of what was budgeted for the project and what the project actually costs. Some programs found that for a high incentive on the cost performance index, managers had the tendency to move costs from one project into other projects or defer actually incurred costs to later periods to maximize the cost performance index. In other words, there is a risk of gaming performance index-based contracts by allocating costs in a way that presents the most favorable picture, all the while remaining in compliance with existing laws and accounting rules.

The last lesson comes from the fact that the bonus rates have to be scaled appropriately or some effects might be lost in the same way as if the bonus rates did not align properly with the desired outcome. There is no use in creating strong incentives for the wrong actions. This is seen in a later discussion on the effectiveness of additional awards in the presence of much larger incentives on other performance indices. For example, if cost reduction is incentivized at a factor of 100 times more than quality is incentivized, then there is almost no reason for the shipbuilder to increase or maintain high quality since it is almost completely eclipsed by the cost reduction incentives.

2.2 Game Theory

Game theory provides the basis to add additional complexity and realism to the principal agent theory.[14] It incorporates a time period sensitive adjustment to the motivations of both parties. If the interactions/transactions between the Navy and the shipbuilders are seen as a trust game in a multiple period scenario then the power of their relational contracts on the relationship can be analyzed.[15]

Either the Navy or the shipbuilder has the right to honor or betray during the game (=total contract period). The Navy when it initially proposes a contract can either trust that the shipbuilder is going to deliver on the contract and proceed with the contract award or not trust the shipbuilder to deliver on the contract and not proceed, ending the game. If the Navy chooses to trust the shipbuilder and the award proceeds, then the shipbuilder can choose to either honor or betray the Navy. This can take many forms for either the entire contract or only specific incentives in the contract. If there is an incentive for the shipbuilder to deliver a ship on a particular timeline, then the shipbuilder could potentially do so while knowing that the ship is not complete and would eventually need to come back for additional repair, retrofits or maintenance.

If the shipbuilder chooses to betray the Navy and charges too much for the ship or does a poor job on the construction of the ship, for instance, then in the next period the Navy would not trust that particular shipbuilder and either not proceed with the contract or enforce some sort of punishment on the shipbuilder. Such punishment could affect the current contract, other parallel contracts or future contracts. This could potentially take the form of a reduction in future incentive allocations or reduced number of ships being allocated to a particular shipbuilder's shipyards for construction. Again, this is a difficult situation to

[14] Gibbons, R. "Lecture Note 2: Relational Contracts", MBA Course 15.903 Organizational Economics and Corporate Strategy, http://web.mit.edu/rgibbons/www/. Accessed April 2013.
[15] This section is derived mostly from the Gibbons and the work done by David Kreps on the trust game.

enforce when there are so few capable shipbuilders for a particular scope of work while still maintaining the necessary capacity for a given ship as well as future ships. Excessive punishment or even a negotiated contract with a utility value *u* for the shipbuilder that is too low could cause that agent or player to withdraw from the market altogether, further exasperating the lack of competition in military shipbuilding.

The analysis that the shipbuilder uses internally when deciding whether or not to accept or reject a certain contract might include a decision tree, as described by Bertsimas and Freund (2004),[16] with each potential outcome including the probabilities of each occurrence. This could include whether they would indeed get punished or receive a reduced end payoff. Each end outcome would have an associated weight to include a component of reputation and professional pride. The shipbuilder could then perform a backward induction to judge the most beneficial course of actions.

[16] Bertsimas, D., Freund, R.,Data, Models, and Decisions: The Fundamentals of Management Science, Dynamic Ideas, 2004.

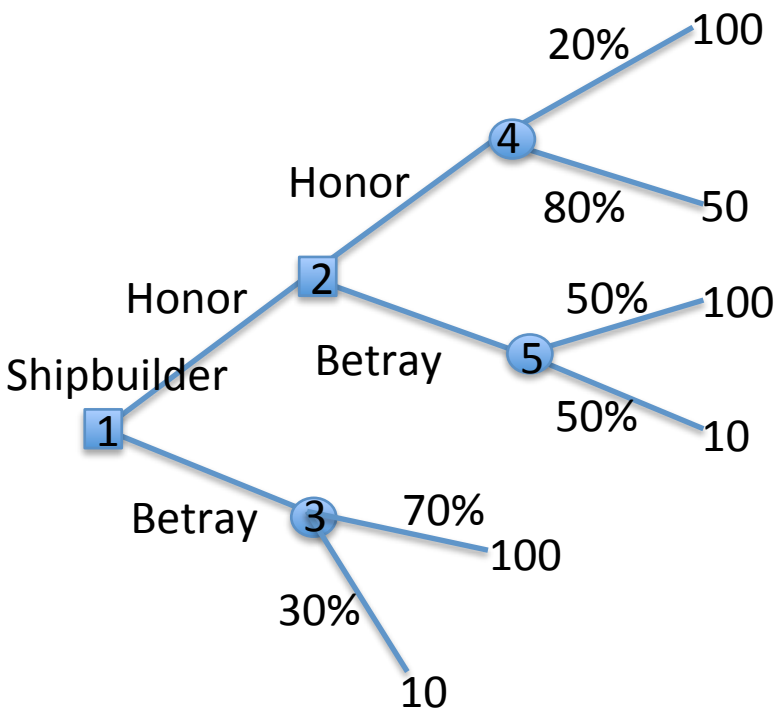

Figure 2 Game Theory Example for Shipbuilding Contract Decision Tree

Figure 2 shows an example of how the backward induction could potentially work for a given situation. The numbers are based on arbitrary probabilities and payoffs. In this figure, first the shipbuilder would look at node four and multiply the probabilities represented as percentages by their expected payoffs to produce the value of that node. The value of node four then becomes 60 and in the same way the value of node five is 55 as seen in Figure 3.

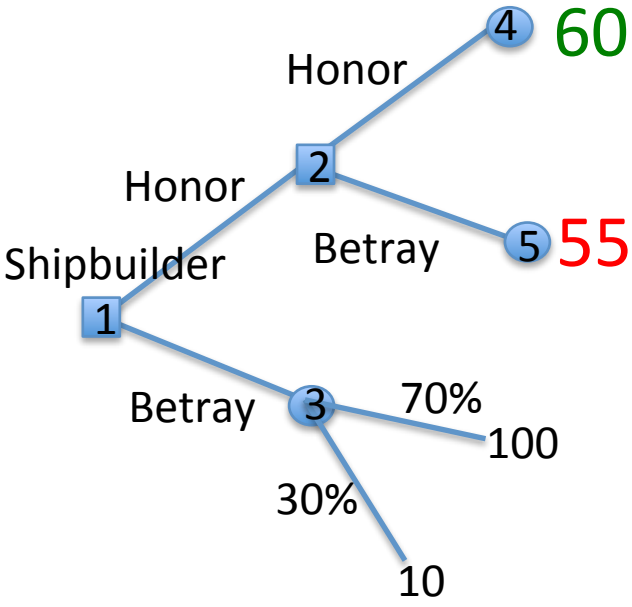

Figure 3 Values of node 4 and 5

In this situation, the shipbuilder would choose to honor the contract in the second period since the potential payoff they would receive from honoring the contract is more than if they were to betray the contract. The value of node two then becomes 60. However, the value achieved by multiplying the probabilities by their associated payoffs at node three gives node three a value of 73 as seen in Figure 4.

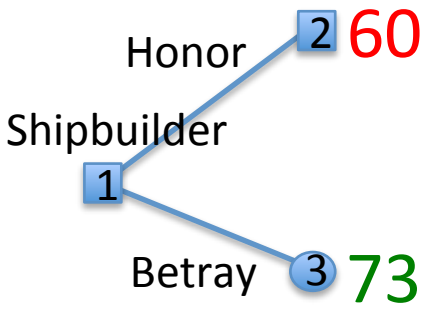

Figure 4 Values of node 2 and 3

This means that it is more attractive for the shipbuilder to betray the contract in the first period rather than continue into the second period. Betraying the contract

in the first period may be equivalent to rejecting an initial or revised contract offer from the Navy, or accepting a contract without a-priori intention to honor its terms or with the intention of locking up the work and renegotiating the contract at a later time. This could be due to several factors to include additional risk in the second period with increased costs for developing an immature technology or potential lack of funding for additional ships. Either way, betraying the contract in the first period creates the most value for the shipbuilder in this case.

Additional factors that would make it potentially more expensive for the shipbuilder to continue on with the contract include scope increases imposed by the Navy during the project. A betrayal in this instance would necessarily be to not comply with the scope of changes since there would be a contracted arrangement for how changes are implemented and what is the equitable payment for those changes. The shipbuilder has to implement the changes. However, a shipbuilder could focus less effort on the quality of additional scope changes or employ less effort in completing the additional portions for a reasonable cost. A rule of thumb discussed with a shipbuilder described cumulative fees associated with changes to the contract in later periods as accounting for about 60% of the total revenue for a contract.

Here the actions taken by the shipbuilder are driven by the potential number of periods and the probabilities and payoff distribution. If there were an infinite number of periods, then it might make sense for the contractor to continue to cooperate. There is a discount rate *r* that can be associated with each of the periods that discounts the amount of future payments to the present value. It discounts the values in later periods so that those periods are worth less than earlier periods. If *r* is too great, then the value of continuously cooperating decreases. Again, *r* is changed by the risk and potential future value of the money not just the inflation rate. If a discount rate of 10% were applied to Figure 2 then the values for nodes 4 and 5 in Figure 3 would be reduced by a factor of

1.1 resulting in a value of only 54 for node 2 making betrayal in the first period even more attractive for the shipbuilder.

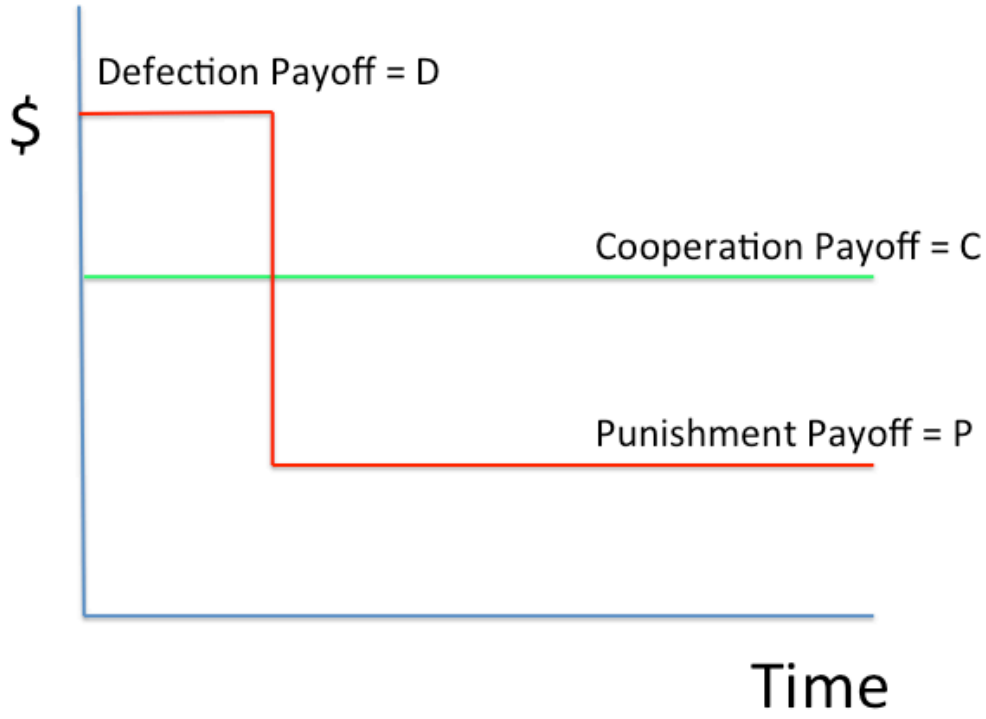

Figure 5 Cooperation and Defection[17]

Figure 5 illustrates the basic example of the tradeoff in payoffs between honoring and betraying. As long as the time value of the money remains less than the ratio of the difference between cooperation (C) and punishment (P) and the difference between defection (D) and cooperation, cooperation remains the best choice for the shipbuilder (i.e. r<(C-P)/(D-C)), cooperation in the long run creates more value for the shipbuilder than the short run temptation to betray the contract and the Navy.

2.3 Shipyard Investments

[17] Gibbons, R., Henderson, R. "Relational Contracts and Organizational Capabilities", 22 December 2011.

After looking at the literature involving the economic theory for analyzing the actual incentive structures, the thesis looked to other potential changes to the current regime that could potentially better align incentives between the Navy and the shipbuilders.

One of the largest factors identified by shipyard CEOs in a 2005 report[18] submitted by the National Shipbuilding Research Program (NSRP) is the stabilization of workload for shipyards. The long range shipbuilding plan released by the Navy for 2014 shows an increase from 282 total battle force inventory to 307 by 2042. In 2005, on average there were four ships per year being produced in the major combatant area. There are currently between five and ten ships produced per year in the US. However, the shipbuilding industry needs to be able to surge to larger capacity. Because of the unstable build rates, there is more pressure for shipbuilders to exact as much profit from contracts as possible in order to avoid potential hiring cycle issues and an eventual reduction in the ability to maintain a skilled labor force. This pressure and contractual volatility also contributes to the overall unattractiveness of the industry for new entrants from tier 2 into the tier 1 area for the construction of large complex naval ships.

The lack of new entrants is a major reason for the small competitive base in the shipbuilding industry. The lack of competitive base produces a sole source environment in which efficient acquisition through price competition is almost impossible for the Navy. Currently about 70% of contracts are awarded as sole source procurements. It is more difficult for the Navy and thus the taxpayers to achieve the most return on their investment into shipbuilding contracts when the tier 1 shipbuilders have so much leverage as the only entities with the capabilities to produce required ships. Apart from the lack of new entrants and sole source characterization of the shipbuilding industry, there is a general lack of eagerness

[18] "Proposed Investment Strategy to Address the First Marine International Benchmarking Study Findings", submitted to DUSD (Industrial Policy) by the Executive Board of the National Shipbuilding Research Program, 01 Aug 2005.

to make large capital investments for facilities improvements that could ultimately lead to more efficient capacity for ship construction.

The NSRP report[19] also identifies an investment framework for the Shipbuilding Industrial Base Investment Fund (SIBIF) with which to address some of those issues. The SIBIF is a fund to be administered jointly by the Office of the Secretary of Defense and the Navy the precepts of which include a multi-year funding profile in order to address and mitigate the inconsistency in build rates and improve the confidence in the Navy's ability to fund more difficult problems.[20]

The initial thought is that a more integrated financial relationship between the Navy and the shipbuilders could much better align the ultimate goals of the two entities. If the value created by the shipbuilders for the Navy has a larger component that is common between the two, then the two would have to be working harder together for their aligned goals. For instance, if the Navy is both a customer and a major shareholder, then the CEO of the shipbuilder is responsible to the Navy on two different levels.

This would need to involve some form of equity-sharing which is not allowed under the Federal Acquisition Regulations (FARs) so a new structure would have to be developed. The case of In-Q-Tel[21] and the SIBIF are reviewed for their structure and how that approach could be applied to an equity-sharing model of the shipbuilding industry as well as the potential application of a search fund model for increased competition in the industry.

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[19] Ibid.

[20] "Global Shipbuilding Industrial Base Benchmarking Study", produced for the Under Secretary of Defense (Acquisition, Technology, & Logistics) by the Deputy Under Secretary of Defense (Industrial Policy), May 2005. http://www.acq.osd.mil/ip. Accessed April 2013.

[21] In-Q-Tel is a not for profit corporation founded by the CiA in 1999. It incorporates many venture capital tools including equity sharing approaches to companies that it deems to have a necessary technology. In-Q-Tel funds them out of the federal intelligence budget in order to help them succeed in a competitive environment in order to maintain the capability to produce those necessary technologies.

It is a combination of these ideas that are used to develop different strategies for improving the interaction between the Navy and the shipbuilding industry. The goal is to produce more efficient contracting between the two where incentives are more closely aligned.

There are many insights to be gained from the Principal Agent Theory and the Game Theory models discussed in the literature. The most important lessons to be gained from these models are the ability to identify key incentives and drivers for both the shipbuilders and the government represented by the Navy. An element-by-element breakdown of the contract structures is required in order to view where each stakeholder is gaining or losing its value. Once those values are identified, it is necessary to think of the relative value produced by different actions of either stakeholder in order to process how one might react to a particular incentive structure.

Increased investment into the shipbuilding industry could produce more efficient contracts and a higher return on taxpayer investment by increasing the competitive base, increasing productivity and changing the sole source environment to more of a free market where price competition is possible.

Chapter 3 Research Methodology

The previous chapter discussed the literature review that was used to form the thought process that was used to analyze each of the contracts that were going to be discussed and the overall industry in which the contracts lie. The four contracts were chosen to give a good sampling of the types of contracts that the Navy brokers with the shipbuilding industry.

After some initial discussion with contracting professionals within the Navy and some of the other members of the PIE study, the Littoral Combat Ship, LPD-17, Virginia Class Submarine, and DDG 1000 contracts were chosen as the most interesting structures for analysis. Those contracts were viewed as the most interesting based mostly on their recency and some unique aspects of their contract/incentive structures. The actual case studies and contract selection criteria are discussed more thoroughly in section 3.2. Additionally, reference points could then be developed for what further interviews with the members of a particular ship program might reveal.

After reviewing the publicly available information, interviews were conducted with each of the offices in charge of each of the four contracts. This information was combined with the information obtained publicly in order to develop an understanding of the motivations considered when the contracts were originally written and negotiated. The contracts themselves were then obtained. The contracts' incentive structures were specifically focused on for further analysis against the motivations revealed in the case studies written about the contracts and the interviews with the key personnel involved in their individual execution.

The contractual incentive structures and motivations were analyzed using the tools discussed in the literature review. These tools include the ability to separate out the actual payoffs or value that each participant in the contract is receiving and then the ability to relate those payoffs and values to actions that either the

shipbuilder or the Navy might take or has taken. The analysis tools give a better awareness and clarity of how different incentives affect the actions of the Navy and the shipbuilder. The results were then discussed and recommendations were made for each structure and the industry as a whole. These recommendations included the discussion of the options for further financial integration between the Navy and US shipbuilders.

3.1 Motivations and Stakeholders

The first step to better aligning incentives between the Navy and its contractors is to identify all of the key stakeholders in their agreements and their main value drivers. These stakeholders and value drivers were discussed with contracting representatives from both the shipbuilding sector and the Navy. There were approximately 30 individuals interviewed including contracting officers from both the Navy civilian and military and the industry, acquisition managers, program managers, deputy program managers as well as senior leadership in contracting and acquisition for the Navy. Initial interviews and discussions took place primarily in November and December of 2012. A sample of the questions asked for each of the programs and the Deputy Assistant Secretary of the Navy (DASN) are listed in the Appendix. From these initial discussions and interviews and information from the literature review, stakeholders and industry motivators were picked out for their relevance.

3.2 Contracts

Using this understanding of the industry motivations and the literature review, the structure of the analysis for the case studies and important information for the contract interviews was established.

The contracts were treated as case studies and important incentive structures that were currently being used were identified in order to analyze their effects on their associated programs. The idea being that we should know where we come from before we can identify where we could or should go.

The first level of selection criteria for the selected contracts was to provide a sample from a relevant time period. For this reason, contracts were chosen for programs that had been acquired within the last 15-20 years. The general lead-time for a ship procurement to go from a bidding to full acquisition is about 10 years. This additional time period gave a greater availability of information about how the contract began and a good sample of its performance. It was also important for the discussion to provide insight into current trends. While it could be potentially interesting to look at contracts for ships in the 1940s, the industrial and economic environment do not necessarily correlate to current trends and many of the key people involved would no longer be available for interviews.

The next level of selection criteria for the selected contracts was that they should be representative of the most prevalent contract types in US shipbuilding. This was actually fairly easy since almost all shipbuilding contracts fall into two categories: Fixed Price Incentive (FPI) and Cost Plus Award Fee (CPAF).

Fixed Price Incentive (FPI)

"As stated in FAR 16.403-1, a fixed-price incentive (firm target) contract specifies a target cost, a target profit, and a target price, which is the sum of the target cost and target profit. The contract also specifies a price ceiling (or ceiling price), but not a profit ceiling or floor, which is the maximum amount that may be paid to the contractor, except for any adjustment under other contract clauses."[24] The contract does, however, specify the profit adjustment formula or the "share ratio"

[24] https://dap.dau.mil/acquipedia/Pages/ArticleDetails.aspx?aid=6794b407-22e0-4d83-aff9-80474fc70014. April 2013.

for both the overrun (cost above the target cost) and the underrun (cost below the target cost).

Cost Plus Award Fee (CPAF)

"A cost-reimbursement contract which provides for a fee consisting of (1) a base amount fixed at inception of the contract and (2) an award amount that the contractor may earn in whole or in part during performance and that is sufficient to provide motivation for excellence in such areas as quality, timeliness, technical ingenuity, and cost effective management. (from FAR 16.404-2)"[25]

Fixed Price Incentive contracts are used primarily when the Navy and the shipbuilders can negotiate firm target cost, target profit, and profit adjustment formula that will be fair and equitable to both parties and provide an incentive and ceiling for which the contractor will assume some of the risk. They place a heavier potential risk on the contractor since unknown costs could potentially reduce the contractor's share by reducing available underrun and thereby reducing the incentive pool for the contractor. FPIs are often used for repeat builds of rather mature designs where prior cost information is available.

Cost Plus Award Fee contracts are used primarily when it is less feasible to identify potential cost structure and objective incentive structures. This situation presents itself in the presence of new or innovative technologies that are implemented on ships. This puts a lot more risk on the Navy since costs are unknown at the outset and the Navy will reimburse whatever chargeable costs that the contractor incurs. Risk can also increase when new technologies or ship types are being constructed since the proper performance metrics may be especially difficult to discern at the beginning and lead to the wrong behaviors being incentivized.

[25] https://acc.dau.mil/CommunityBrowser.aspx?id=37757. April 2013.

The final selection criteria for the selected contracts were that the contracts should have different incentive structures in order to provide a spectrum for analysis. The contracts chosen as case studies are shown in Table 1:

Cost Plus Award Fee	Fixed Price Incentive
DDG 1000	Littoral Combat Ship (LCS)
LPD 17	Virginia Class Submarine (VCS)

Table 1 Shipbuilding Contracts for Analysis

The DDG 1000 and the LPD 17 were chosen mostly for the new technologies that they were trying to incorporate. They are good examples of the Cost Plus Award Fee contract situation where it was difficult to set a cost at the outset of the program because of the new technology integration. They also each had some unique award structures and final delivery issues. Because of increased the cost of the DDG 1000 combined with the inability to justify additional funding, the program was reduced significantly during its acquisition cycle. It was reduced from a potential of 32 ships to an ultimate delivery of only three. The LPD 17 was very far over budget and delivered late and before it was fully constructed.

The LCS had a very interesting procurement development. It started with a Down Select procurement strategy and moved to a Dual Award Strategy, both of which included a large block buy provision. The Virginia Class Submarine was chosen mostly for its successful ability to reduce its cost structure and implement a successful Capital Expenditure plan maintaining the share ratio as the largest motivator for its shipbuilder. It is especially important as a case study because of the cost savings it was able to achieve in the same sole source environment other Navy programs are operating in, while being an extremely expensive program overall.

Chapter 4 Stakeholder Findings

For shipbuilding contracts, there are four main groups of stakeholders: Navy, contractors, Congress, and the citizens. For this discussion, the citizens will be combined with the interests of Congress and Congress is ideally a representative of its citizens.

All three of these groups have different objectives and goals, making alignment of incentives critical in order for each group to achieve their individual goals. In this situation and from the perspective of the Navy, the end customer is Congress and the supplier is the contractor. This relationship is represented in Figure 6. An indirect relationship exists in that contractors give jobs in geographical areas where shipyards are located and these locations map to specific congressional districts. There is therefore a complex bi-directional relationship. For the purposes of this thesis we will, however, only consider the role of congress in promoting national security while funding the Navy, not its role in providing jobs to citizens in various districts.

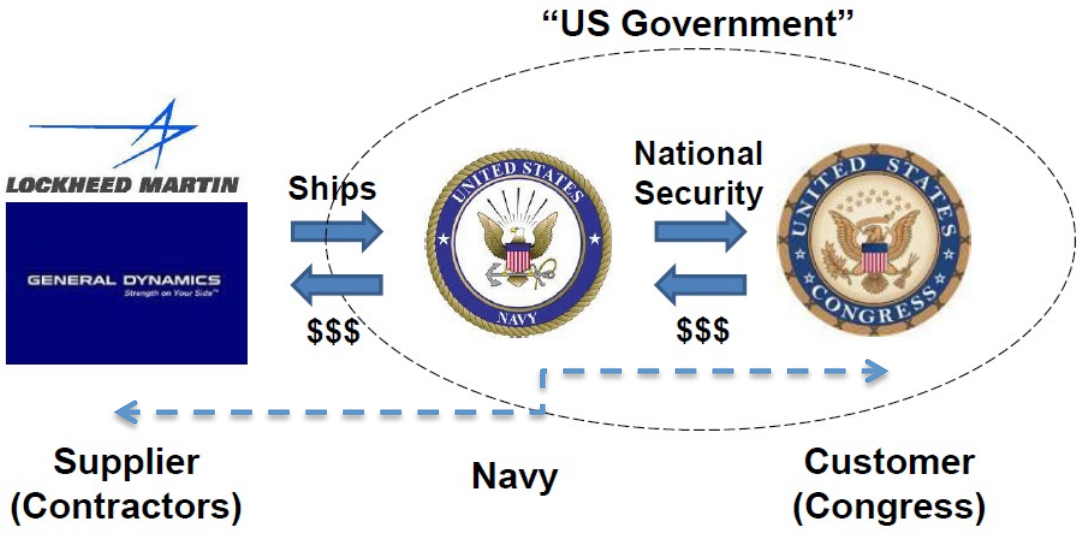

Figure 6 Supplier/Customer Relationship in U.S. Shipbuilding

The end product is transformed at each transaction step. The product transforms from ships in the interaction between the Navy and the contractors to national security in the relationship between Congress and the Navy. The dotted line encircling the Navy and Congress represents the fact that their interests are generally aligned as the ships procured by the Navy create the national security that Congress wants. However, the two individuals can have very different concerns with regard to the budget for procuring those ships.

The goal of Congress in this regard is to protect its citizens at the lowest cost possible. With the taxpayers' money, Congress allocates financials resources to the Navy to allow the Navy to carry out its national security function. In addition to funding the Navy, however, Congress must also provide funding for other social services and the other armed forces. The multiple funding requirements make efficient usage of funds critical to Congress' success. An effective Congress therefore identifies key programs and allocates the minimum sufficient funding for those programs to be successful.

Each Congressman is elected by his constituency. This creates a driving force for Congress to make their constituency happy thereby obtaining reelection. Poor selection of projects and poor allocation of funds will prompt the constituency to elect a different representative. To the average citizen the net benefit from funding Navy programs is only obvious during wartime; Congress would do best to limit unnecessary spending on Navy projects.

The goal of the Navy is to serve Congress' through protection of US citizens through direct and indirect military action. The official wording of the Navy's objectives is "influencing by power and projecting the nation's influence across the seas to the waters and shores of foreign states both in peace as well as wartime. "[26] These objectives can create a conflicted position for the Navy. The Navy receives funding from Congress giving it the incentive to maximize the

[26] http://www.fas.org/news/russia/1995/druma172_s95009.html. Accessed April 2013.

value created per dollar spent by Congress. If the cost of the programs requested for funding by the Navy grows too large, the programs could potentially be denied or cancelled. Specifically, there is a provision called the Nunn-McCurdy Act (10 U.S.C. § 2433), which requires the DoD to report to Congress when certain thresholds are exceeded.

A significant breach to the Nunn-McCurdy Act occurs when the total cost of a unit in the acquisition process exceeds 15% of the current baseline estimate or 30% from the original baseline estimate. A critical breach occurs when the cost exceeds 25% of the current baseline estimate or 50% over the original baseline estimate. When significant breach occurs, it triggers a report to Congress and increases the cost growth visibility of the program. A critical breach will result in termination of the project unless the Secretary of Defense certifies the program. [27]

Although reducing cost should ostensibly be in the interest of the Navy, there is potential for both positive and negative externalities. Reduced cost for programs creates a better relationship between the Navy and Congress, which might increase the likelihood of getting future projects approved. However, Congress may take the reduced cost as a sign that the current Navy allocation is too high and reduce the size of future funding. For this discussion, it is assumed that the Navy's goal is to reduce the cost of its programs while maintaining a high level of quality and schedule adherence. Though the effect of potentially receiving less future funding is worth mentioning.

The Navy must also develop effective relationships with its contractors. Because of the Jones Act and other restrictive laws that create barriers to entry for foreign contractors in the US shipbuilding industry, the Navy must maintain an attractive environment for those shipbuilders whose main revenue source are Navy

[27] Schwartz, Moshe, "The Nunn-McCurdy Act: Background, Analysis, and Issues for Congress", Congressional Research Service, June 21, 2010.

contracts in order to keep them in the shipbuilding industry and maintain a certain level of long-term industrial base for the US in order to counteract potential wartime situations. The Navy must then leverage its resources in order to satisfy the financial interests of these for-profit contractors to keep them in the shipbuilding industry and continuously innovate in order to keep the US at the forefront of Naval technology. Without innovation from its contractors, the Navy's military capabilities would lessen over time and devalue the Navy's contribution to national security.

The contractors want to produce ships and systems for the Navy that create value for the Navy and contribute to its mission. The major contractors, GD and HII, are however, publicly traded, for-profit companies who are responsible to their shareholders. GD and HII need to provide value to their shareholders by generating profits and increasing returns on investments. Even though there are only two major players in the US shipbuilding industry for large ships, they still have to win bids and successfully complete the awarded contracts in order to generate profits. These two major tier 1 contractors also pass on subcontracts to suppliers at lower tiers of the supply chain.

Contractors would ideally like to be able to maintain a full yard with a stable production process to limit the effect of layoffs and hiring cycles. A constant employment force makes their company more attractive for employees while maintaining their technical proficiency. That technical proficiency adds to the "brand" or status of the contractor as a whole. An improved reputation plays into the successful completion of awarded contracts while allowing the contracts to lower their bids because the actual man-hours required to complete a project are less. However, since ship contracts and costs are agreed to by analogy (a ship's cost is based on what a similar ship previously constructed cost the Navy), a lowering of current costs charged to the Navy could reduce the baseline for future projects.

Table 2 summarizes the motivations and concerns for the three major stakeholders in the Navy's shipbuilding supply chain.

Stakeholder	Motivation/Concerns
Congress	• National Security • Optimal resource allocation • Constituency

Navy	• National Security
	  ○ Technological Innovation
	  ○ Fleet Size
	  ○ Industrial Capacity
	• Full Funding for Projects
	• Efficient use of available funds including:
	  ○ Level of Quality
	  ○ Vessels delivered on Schedule
	• Maintaining differentiated value from other services

Shipbuilders	• Stable workload
	• Differentiated capabilities from competitors
	• Maximize value to shareholders by maximizing sharevalue
	  ○ Profit = Revenue – Cost
	  ▪ To ↑Profit, either ↑Revenue or ↓Cost
	• Reputation
	  ○ Leads to increased Revenue by winning bids

Table 2 Summary of Stakeholders and Motivations in US Shipbuilding

Chapter 5 Contract Case Studies

The goal of the contract case studies is to identify similarities between programs and methods in dealing with the shipbuilding industry over all and potentially places where inefficiencies are present and could be improved. The contracts give a good starting point for future potential innovation.

5.1 Cost Plus Award Fee

The following two contracts are classified as Cost Plus Award Fee. They both include the integration of several newer technologies. These contracts are especially rich in incentive structure since the additional bonuses are the largest motivating feature in them.

5.1.1 DDG 1000

5.1.1.1 DDG 1000 Background

The DDG 1000 began its life as the DD-21 or “destroyer for the 21st century” it then went through another iteration as the DD(X) where it was classified as destroyer whose design was in development. It became known as the DDG 1000 or a guided missile destroyer with the hull number 1000. It was meant to improve the capability to defend littoral waters while incorporating several new technologies.

The DDG 1000 meant to reduce its crew size from around 300 on most destroyers and cruisers to 142. The crew size reduction would be possible through heavier automation and the implementation of an electric drive propulsion system. The ship also incorporates a wave-piercing, tumblehome hull

for reduced detectability, a superstructure with large composite sections rather than steel or aluminum, a new advance gun system (AGS), a new kind of vertical launch system for storing and firing missiles, and a total ship computing system to help manage information about the ship.

The estimated displacement was 15,482 tons, which made it nearly twice the size of most cruisers and destroyers. The first two DDG-1000s were procured in FY2007 at an estimated cost of $7,795.2M USD with a third procured in FY2009 at an estimated cost of $3,674.9M USD.[28] All ships were to be constructed at Bath Iron Works, a shipyard owned by General Dynamics with portions to be constructed and delivered by Huntington Ingalls.

Initially the plan for the construction of the first two ships was to have the first completed at a GD shipyard and the second at a HII shipyard. As the program progressed it was agreed that all three ships would be constructed at GD shipyards and a greater portion of the DDG 51 (another program that had been increased as the DDG 1000 was decreased) was to be constructed at the HII shipyards. In 2010, the program experienced a critical Nunn-McCurdy breach. The Navy stated that the breach was a consequence of the reduction in the number of ships. The original program was reduced from 32 to 3. This meant that the $9.3B USD that was allocated to the research and development of the program had to be spread out over a program of 3 rather than 32. The unit cost increased by a large amount. [29]

Owing to this critical breach, the program was restructured and the new radar that was supposed to be implemented, the volume search radar, was removed from the ship design. This removal was estimated to reduce the total program cost by around $300M USD. After the restructuring, a letter from the Cost Assessment and Program Evaluation office, part of the Office of the Secretary of

[28] O'Rourke, R. "Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress", Congressional Research Service. 18 October, 2012. p. 6
[29] IBID., p. 50

Defense), was attached to the certification after the breach estimating a 50% probability that the program would remain at or below the new estimated cost of $4.3B USD which was 17% above initial estimates. As of 2012, the first ship was estimated in a March 2012 GAO report to be 63% complete. [30]

5.1.1.2 DDG 1000 Incentive Structure

The incentive structures in the contract itself included a Cost Plus Incentive Fee portion for the overall construction and the development of the new vertical launch system. The structure of these line items was negotiated and modified from the initial procurement strategy where they would have been treated as Cost Plus Award Fee. The structure of this incentive fee, much like the fixed price incentive fee provides for a share line that allocates ownership for both BIW and the Navy in both underrun and overrun scenarios. The potential for the each of these contract line item incentives included a maximum of close to 20% of the estimated target cost in the case of underrun with a minimum incentive of about 7% in the case of large overruns.

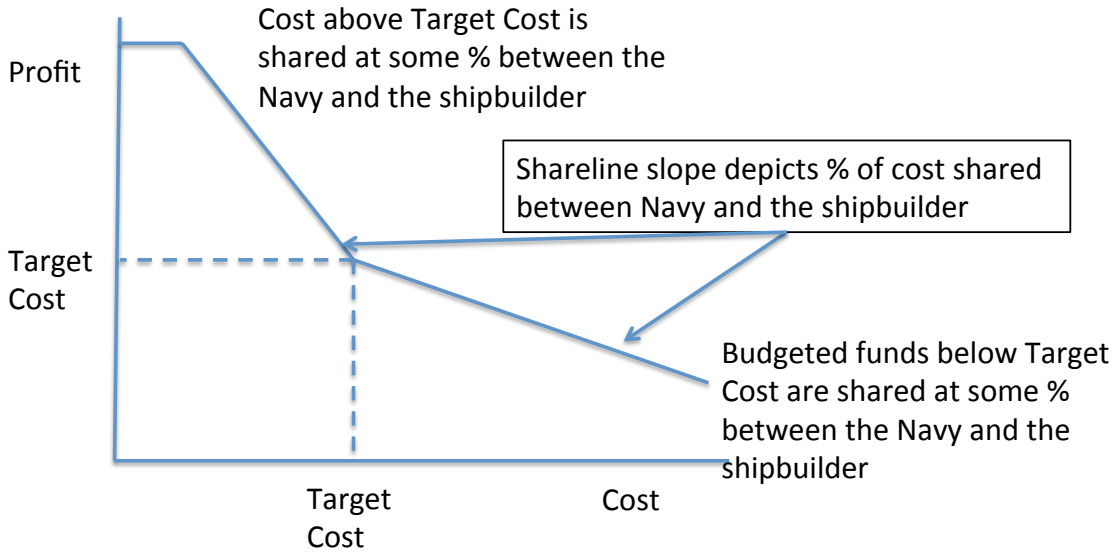

Figure 7 Shareline

[30] IBID.

The design and research and development of the ship were given incentives based on a specific award fee. These contract portions were Cost Plus Award Fee. These line items in the contract carried the most potential risk since it was here that the new technology implementation was to be included. These provisions included both period-based and event-based components. Period award fees are those award fees allocated during different periods of time and judged for established criteria at the end of the period. They could potentially be lengthened or shortened, but they are assumed as written into the current contract. Event based awards are those awards given for specific events or milestones completed by the shipbuilder.

The period award fee amounts carried a much larger potential payoff than the event based award fee and included components of quality, schedule/plan execution, and cost. The period awards are more subjective than the event based awards. The event-based awards had more specific components or “boxes” to be checked in their completion. The detailed design for instance was given both a period based and event based award. The period based award was subjectively assessed based on quality, cost, and schedule execution. The event based award had more specific milestones contained within it. The ability to start fabrication for instance contributed to the amount of the award received.

There were also included in the contract some special incentives of proportionally trivial amount when compared to the period and event based award fees. These incentives were focused on a readiness to begin production at a specific date and the ability to implement of changes within a certain time period.

The DDG 1000 was not a successful program by the cost threshold criteria. The program had exceeded over 17% of initially budgeted cost and came in much later than expected. The contractor was still able to receive a large percentage of the event and period awards stipulated in the contract. This type of incentive was

again one of the only motivators toward end of the acquisition due to the lack of potential award along the shareline. The loss of incentive for performance along a shareline occurs if, for instance, the incentive is for 50% of whatever the positive difference is between the actual cost subtracted from the target cost. Once the actual cost meets or exceeds the target cost, then there is no incentive for cost performance along the shareline and in the case of the DDG 1000 only the period and event potential awards exist.

5.1.2 LPD 17

5.1.2.1 LPD 17 Background

The LPD 17 program was initiated in the 1990s in order to replace the LPD-4. It was meant to improve overall amphibious capability for both combat and non-combat operations. The amphibious warfare community conducts a large number of operations in both of those areas.

The LPD 17 design included an advanced enclosure mast system as well as a new computer program that could enable the ship to be designed in its entirety by computer programs. The ship also includes several additional stealth features such as the deck edges being bounded by bulwarks and the anchor and anchor pocket shaped to minimize backscatter. The ship incorporates several crew comforts as well such as in rack fans and lap top desks.

The LPD 17s are built primarily by HII at their Avondale and Pascagoula shipyards. The first one was procured in 1996 with 10 having been procured through FY 2010.

96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
1	0	0	1	2	0	0	1	1	1	1	0	1	1	0

Table 3 LPD 17 Procurement, FY 1996-FY2010[31]

The program experienced considerable cost growth, schedule delays, and construction problems. Some of these issues can be attributed to the effects of Hurricane Katrina on the capabilities of one of the HII shipyards, which interrupted final delivery of the 2005 ship, and the construction of the subsequent two ships. The third ship of the entire program, delivered in 2000, was the first ship that was delivered without significant problems. The entire program cost grew by about 70% over initial estimates and had considerable delays in production, which were primary reasons for the gap in procurement between 1996 and 1999.

The Navy actually accepted the first three ships in the LPD 17 class with over 1.5M combined construction hours remaining. The reasoning for accepting the unfinished ships given by the Navy were[32]:

- Sooner potential evaluation of problems that could be addressed in later ships of the class
- Sooner opportunity for the crew to begin familiarization with the ship
- Sooner migration out of the shipyard to avoid schedule and cost impacts on other ships
- Reduced cost because remaining work could be conducted at repair yards with lower rates than the new construction shipyards.

5.1.2.2 LPD 17 Incentive Structure

[31] O'Rourke, R. "Navy LPD-17 Amphibious Ship Procurement: Background, Issues, and Options for Congress", Congressional Research Service, 15 October, 2010.
[32] IBID.

The LPD 17 contract was initially written to include the options for the construction of the first four ships of the class: LPD 17, LPD 18, and LPD 19. The construction of these ships was written with an incentive fee similar to the fixed price incentive contract with a share line to express the allocation of ownership for both the overrun and the underrun of a target price. The share line would increase the amount for which the shipbuilder was responsible while decreasing the potential payoff for the underrun. This is most likely the result of the assumed increase in proficiency as the shipbuilder spent more time building the same type of ships (i.e. the presence of a substantial manufacturing learning curve). This was a phenomenon that was later argued by the Navy in requesting continued funding for more ships of the class since the LPD 17 had potential for use as the base hull in a later class of ships.

The design of the ships as well as the construction of LPD 19 had an award component to them as well, creating a Cost Plus Award Fee structure. The largest component in the evaluation of these awards came as Period Awards. The period awards were much less than the potential for award in the incentive fee on the order of 5-15% of those potential awards. The relative size of incentives can be seen in Figure 8. Each evaluation period would be evaluated based on several subjective measures on a performance continuum from “Minimally Acceptable” to “Outstanding” with an appropriately scaled percentage of the award feel based on that continuum. The period awards in this instance also had a few interesting features.

- If the contractor was only going to achieve the minimum fee, then the Navy could use a percentage of the award fee to incentivize cost performance.
- The Navy could carry fee up to half of the unearned award fee into future periods. The Navy always has the option written into its contracts to be able to de-obligate any unearned award fee.

- The Period Awards themselves were more heavily weighted toward the end of the contract.

There was a performance incentive attached to the construction of the LPD 17 and LPD 18. The fee was less than 20% of the potential award fee for the share line incentives and were meant to reward “special” contract efforts in several areas including:

- Program Management
- Design Quality
- Subcontract/Vendor Management
- Material Procurement
- Quality Assurance
- Production Processes
- Test Planning/Execution
- Lifecycle Cost Reduction

Each of these criteria would be scored and given equal weighting to provide a score out of 100 that would be used to scale the amount of the performance incentive award. These awards were payable bi-annually based on an award fee pool, which was fairly steadily spread out over the total potential award for each of the ships. In this case, an unearned fee could be rolled into 1 future period.

Another performance incentive was attached to the LPD 20 construction cost performance. It was similar to the share line, though there was no sharing included. If a certain cost threshold was achieved, the shipbuilder would receive about one percent of that cost as an award. Below that threshold, the shipbuilder would receive 50% of the difference between the threshold and the actual cost. Above the threshold, the incentive was reduced itself by 20% for every one percent over the threshold. (i.e. a two percent increase over the threshold

reduced the incentive by 40%, but a 1.5% increase over the cost threshold only reduced the incentive by 20%)

The LPD 20 also had a delivery performance incentive that had both a cost and time component associated. If the LPD 20 was delivered by a certain date and still below a certain cost threshold then it would receive about .5% of total cost as an incentive with a reduction for every dollar above the associated cost threshold. The LPD 17/18 had a delivery incentive where the contractors were to receive a fixed sum if the ship were delivered before a negotiated date. There was no cost component associated with this incentive.

The LPD 17 had several additional possible awards for milestone completions in the launch and light off phases of construction, compartment completion, and crew move aboard. The crew move aboard was specifically affected in light of Hurricane Katrina when the ship itself was used by Navy divers and shipyard workers for housing during cleanup efforts.

A final contract performance incentive was also included as a potential award which gave the shipbuilder the potential to recuperate a large amount of any unearned award fees. This award was to be evaluated after the end of the agreed upon three year guarantee if no additional problems with the ship were found.

It was found that the share line had little effect on the motivation of the shipbuilder since they had been pushed up so close against it. There was no real continuous motivation because there was such little potential to pursue additional fees. It must have been similar in the case of the final contract performance incentive where the ships had already experienced so many problems that there was no potential for them to actually receive this award. The office in charge of the programs found that it was necessary to add additional incentives for specific areas they saw needing improvement in a particular shipyard. This late addition

of incentives to the contract is not an ideal situation for the Navy or the shipbuilder. There were no specific productivity investments as in the VCS program just very targeted incentives to complete a hydrostatic piping test successfully for instance.

5.2 Fixed Price Incentive

The following two contracts are classified as Fixed Price Incentive contract structures. Though they may contain some additional incentives, the largest component to the contract incentive structure is the share line with a ceiling price. In these cases, the total structure of the contract and bidding structure as well as the pursuit of additional cost reductions and facilities improvements will be the more interesting discussion.

5.2.1 Littoral Combat Ship (LCS)

5.2.1.1 LCS Background

The Littoral Combat Ship (LCS) was awarded as a preliminary design contract in 2003 and the keel for the first ship of the class was laid in 2005. Since then, three ships have been delivered with a fourth preparing for trials and an additional eight in various stages of construction. The LCS is a surface combatant built with modular mission packages so that it can be equipped to handle a specific mission type at a time. Think; pick up truck of the Navy. The mission package is what is driving the performance of a particular mission and the LCS is just getting the package to the right location.

The LCS is designed to be fast and maneuverable with a shallow draft so that it can reach places that most cruisers and destroyers cannot. The mission packages are focused on several critical gaps including:

- Mine Warfare
- Small Fast Surface Craft
- Diesel Submarines

The open system architecture includes onboard sensors, weapons, and command and control and the incorporation potential for unmanned vehicles.

Initially, two competing designs were created; one by General Dynamics and the other one by Lockheed Martin. The Lockheed design is a steel semi-planing monohull and the General Dynamics design is an aluminum trimaran hull. The LCS displaces about 3,000 tons and has a maximum speed of 40 knots compared to a little over 30 knots for the maximum speed of Navy cruisers and destroyers. [33]

The Navy awarded the full final construction to two different shipbuilders. The design created by Lockheed Martin is built at Marinette Marine shipyard in Wisconsin. Lockheed is a minority stakeholder in Marinette Marine. The General Dynamics design is built by Austal USA shipyard in Mobile, Alabama. Austal USA is a joint venture between an Australian shipbuilding company, Austal Limited of Henderson, and Bender Shipbuilding and Repair Company of Mobile, Alabama.[34]

The contracted cost of the LCS program doubled since the initial cost estimation. Additionally, there have been several quality control issues including hull cracking, engine problems, and corrosion. The mission modules have also been seen to require much more time to change between deployments than was originally estimated. [35]

5.2.1.2 LCS Bidding Structure

The first proposed agreement structure for the LCS construction contract was the Down-Select process. The down select process involved taking competitive bids from each of the two shipbuilders by allowing them to each construct a single

[33] O'Rourke, R. "Navy Littoral Combat Ship (LCS) Program: Background and Issues for Congress", Congressional Research Service, 10 August, 2012.
[34] IBID.
[35] IBID.

LCS design first. The most cost-effective and best-performing design was then chosen for a block of 10 ships to be constructed by the winning contractor. A second bidding was then held in the second year for five additional ships to be built by a separate contractor with the same winning design. The winner of the first bid would also, at the Navy's discretion, construct the combat system for the second source as an additional incentive. The two sources would then be at a constant competition for the next phase of construction in FY15 as seen in **Table 4** (top). Some of the most important points beyond the timing-logistics were:

- Intent for entire block of 10 ships to be built in one shipyard
- Continuous competition for the two shipbuilders for LCSs procured in FY15 and subsequent years
- First bid winner could not compete in the second bid
- Single design after downselect
- Ability to use the level of efficiency and cost at one ship yard to benchmark the other

		FY10	FY11	FY12	FY13	FY14	FY15	TOTAL
Downselect	Winner	2	2	2	2	2	4	19
	Second Source			1	2	2		
	Total	2	2	3	4	4	4	
Dual Award	Contractor A	1	1	2	2	2	2	20
	Contractor B	1	1	2	2	2	2	
	Total	2	2	4	4	4	4	

Table 4. Shipbuilding Schedule with LCS Downselect versus Dual Award Structure

The Dual Award selection process was then proposed along **Table 4** (bottom) where two blocks of 10 LCS contracts would be awarded to two different contractors. Each contractor would design its own version of the LCS and pursue the construction of its own subsequent block of 10 using that design. The Navy would then be able to abandon either contractor at any point along the proposed schedule if that contractor was not meeting certain cost and performance metrics. Some of the most important points to the dual award contract beyond the timing and major logistics included:

- No orphan LCS ships created
- Potential to neck down to single LCS design providing time for evaluation
- Maximum procurement rate of four ships per year beginning in FY11

Understanding the Down Select Contract Structure

As discussed earlier, the Navy was faced with the decision of pursuing a down select contract or a dual award contract for procuring its LCS fleet. The down select contract was seen as having the following benefits:

- More competitive bidding, resulting in lower prices (Congress benefit)
- Single fleet type, reducing maintenance costs and staff training due to fleet commonality (Navy benefit)
- Better economies of scale for contractors, reducing production costs (Contractor benefit)
- Option to continue use of initial contractor weapon systems, resulting in cheaper costs and greater profits for initial contractor (Congress and contractor benefit)
- Single contractor, requiring less logistical and management costs (Congress and Navy benefit)
- Contractor change every several years, allowing more flexibility (Navy benefit)

Although the down select contract seemed like a logical solution from a cost perspective, there are obvious flaws in this type of structure. The biggest issue is that the single contractor has enormous leverage, and thus potential for hold-up, as they will be the only firm providing ships if selected. They could easily lowball their bid, and once selected, force changes in the contract midway through the project or even request a potential bailout if things go even worse than planned. The Navy and Congress would have little choice but to agree with the failed program or contractor or cancel the whole program and abandon the capabilities provided by LCS with potential negative impacts on national security.

There is also the issue of no matter how well you define the contract; there are elements you can't control through formal contracts. How would the Navy be sure that deeper quality issues aren't present beyond the specifications? There needs to be some form of control then through informal means to promote that quality. That could potentially be enforced by the probability of receiving future work from the Navy as some function of reputation especially in the presence of many competitors.

The last key issue was that due to shorter contracts, the chances of defection were greater since the relationship would not be growing over a long period of time. The contractor has the option to defect on three major areas: cost, schedule, and quality. A relationship that does not include multiple periods would increase the probability that the contractor would defect on one of these elements. The Navy on the other hand could defect by cancelling or reducing ships, or renegotiating contract specifications. Such a relationship seeds distrust on both sides and damages the ability to develop strong relational contracts.

Understanding the Dual Award Contract Structure

The dual award contract was the other contract structure that the Navy was considering in place of the down select contract for the LCS program. It was seen as a better alternative for the following reasons:

- Contracts for both ship builders would be longer providing better return on investment (Contractor benefit)
- Competition between two contractors would keep long-term costs in check (Congress benefit)
- Common combat systems would allow for standardization of add on weapons while diversifying risk of creating new hull technologies (Navy benefit)
- Increased production of ships getting them into service quicker (Navy benefit)
- Eliminate costs related to orphan ships not selected in down select contract (Congress benefit)
- Ability to eliminate a contractor if unable to meet cost or design specifications without jeopardizing ship delivery (Navy benefit)

Beyond these cited reasons, there were a number of other benefits that came with pursuing such a strategy. With regard to hold-up, now the Navy had two contractors to choose from so if one contractor had tried to force contract changes the Navy could shift to the other contractor. The existence of the Navy as the only major customer of the contractors also eliminated hold-up that would be possible in usual contractor relationships, as contractors had no other customers to use as leverage.

This would also address the other big concern that it is hard to manage a relationship solely through a formal contract. If another contractor is present, the desire to defect and break the contract is less enticing. The contractor will want to maintain a good reputation with the Navy so it wouldn't be cut out of the contract if considerable quality or other issues arose. There is also a greater

chance of a growing relationship as the contract is longer, thus reducing defection probability. This lower defection probability would foster a more trusting and productive relationship, allowing better relational contracts to be formed over time.

The flaws of pursuing a dual award contract would be lower economies of scale as you are splitting the contract, as well as less initial bid pressure since two contractors will be selected. The Navy will also see increased costs in program management in overseeing two different designs. Although, the initial cost analysis against both of these showed in a Navy briefing to the Congression Research Service (CRS) and the Congressional Budget Office (CBO) on March 30, 2011[36] showed that the dual award contract will be cheaper over the life cycle of the project as there aren't orphan costs and second sources (sources after initial contract startup) will experience significantly higher costs related to learning curve, vendor costs, and rework.

The Dual Award contract structure was eventually chosen for the LCS program. The contracts were awarded to both Austal USA and Marinette Marine for construction. In this instance, we see the addition of two new competitors for large ship builds. In order to do this, Austal Limited used the tier 2 shipbuilder Bender as a base and then injected a large amount of capital to be able to win the award by making themselves more attractive and more capable. This is an instance of a foreign company potentially subverting the Jones Act in order to participate in the US shipbuilding industry in a major way. A provision was also included in the contract that Austal would be investing heavily in themselves in order to improve capability and capacity to the required level for large-scale production of the LCS. This was most likely a requirement to show the commitment and future capability to produce the ship at the required capacity. Interviews with the program office for the LCS and additional reports indicate that

[36] Ibid.

the added competition and the Dual Award structure contributed to the overall success of the program.

5.2.2 Virginia Class Submarine (VCS)

5.2.2.1 VCS Background

The Virginia Class Submarine is an "attack" type submarine designed for a post cold war environment. The design leverages several newer submarine technologies and much of the design effort from the Seawolf Class submarine which was initially set for a total procurement of 30 boats but was reduced to three due to the reduced threat environment when the Cold War ended in the early 1990s.

The first Virginia Class Submarine entered service in 2004. The procurement schedule was designed as either a block buy or a multi year procurement strategy in which several boats were contracted at once. This gave the Navy the opportunity to take advantage of economic order quantities to increase cost savings by spreading out the cost of each individual submarine and reducing the marginal cost. The Navy estimates a potential cost savings of just over $3B USD in net present value owing to the multiple ship procurement. [37]

The construction of the ships is divided between shipyards owned by both General Dynamics and Huntington Ingalls. Although it is not a formal Dual Award structure, the character of the agreement between the two basically divides the profits for the construction of the submarine in equal parts between the two major companies by providing both shipbuilders with components of the submarine to construct and alternating the construction of the reactor compartment. This

[37] O'Rourke, R. "Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress", Congressional Research Service, 2 April, 2012.

division serves two purposes: maintains larger industrial base to ensure that potential capacity for submarine construction will be met and minimizes the cost penalty associated with using more than one yard when the procurement rate is low.[38]

The program made a large effort to reduce the cost of each submarine to around $2B USD in order to increase the potential number of units procured. This was done by changes in the boat design as well the production processes and reduction in the timeframe the boats resided in the shipyard during construction. A large part of the cost savings was also assumed to come from the increased order quantity.

5.2.2.1 VCS Incentive Structure

In the VCS contract, special incentives were included in addition to the incentive on the share line. The potential for special incentives was about 25% the size of the potential for additional earnings on the share line. The addition of the special incentives allowed for additional negotiation power with regard to the placement of the share line and the target costs.

The special incentives included a performance incentive based on

- Design Quality
- Cost Performance
- Drawing Schedule Performance
- Affordability/Producibility
- Program Management

[38] IBID.

The performance incentive was evaluated along several periods with a much higher allocation from the entire incentive fee pool for the performance rather than the cost. The performance was more than forty times the cost incentive. A larger cost incentive might have been redundant because of the share line.

The incentive on the first block of ships was focused on the reduction of cost of design and construction and improvement of submarine capabilities. The award fee pool was significantly larger than the performance incentive. In the construction of later blocks, the focus was on schedule performance, total cost control, reduction of labor and material costs and some additional incentive on utilizing small businesses. As the blocks of ships procured increased, the focus was almost entirely on schedule and performance with decreasing amounts allocated to each of those incentives including a tightening of the share line. The share line incentive provided a much larger payoff than the other incentives and actually drove the cost performance of the shipbuilder significantly according to interviewed sources. This is in contrast to the LPD 17 program in which the share line did not drive cost performance at all.

There was also a provision for the Navy to allocate a large amount of capital for the improvement of facilities based on a business case analysis provided by the shipbuilder. This incentive is focused on improving facility capability to improve efficiency and potentially further reduce costs. The shipbuilder provided several case studies in order to justify additional facilities improvements. This is in contrast to the DDG 1000 program that had a similar clause allowing for additional capital expenditure included by the Navy for facilities improvements and other efficiency capabilities of which they did not take advantage. There were no business case submissions by the company for additional capital expenditure funds from the Navy to improve production efficiency. This difference in the drive for cost performance could be a direct result of the contract structure in which the payoff was driven so much more by the share line. Interviewed sources also point out that the shipbuilder was eager to drive cost down as soon

as possible because of the share line and not the schedule incentive. If the shipbuilder were able to show the projection for a particular evaluation period as being lower than that, which was expected, then they would be eligible to begin to receive the appropriate bonus. This maintained a higher level of cash flow in the program which gives the shipbuilder more flexibility for additional internal investments and productivity improvements.

Fixed Price Incentive contracts have generally been used in situations where there are few unknown costs. This would generally preclude projects that included many new technologies. The VCS program was a good example of the ideal program for Fixed Price Incentive use. The design itself was leveraged off a previous design and the shipbuilder was able to focus on the reduction of costs that were already understood and there was room for the shipbuilder to explore more creative opportunities for cost reduction because of their high level of understanding. The LCS was more expensive than originally estimated, but the estimate was justifiable by the Secretary of the Navy because the hull type at least was understood. There were several newer technologies incorporated into the LCS design which would have made it less desirable for a Fixed Price Incentive contract, but additional competitive base (a second viable supplier) allowed for more flexibility on the part of the Navy to request this type of contract. The Fixed Price Incentive generally puts more risk on the part of the shipbuilder because as we saw in the cost share line associated with the LPD 17, unbudgeted costs can eventually lead to loss of the ability to gain additional incentive from that share line. When the target cost is properly estimated, however, the share line in the Fixed Price Incentive contract can provide a much larger incentive for shipbuilders to produce a quality product on time at a reduced cost. There is an especially large potential for cost reduction, but when the added dimensions of reputation and competition are put incorporated, better quality and schedule adherence can be achieved.

Chapter 6 Incentive Analysis

The main values that the Navy focuses on in their incentive structures are the quality, cost, and schedule. Therefore in the language established during the literature review, the total firm value:

$$y = y_c + y_q + y_s$$

y_c – value associated with cost reduction
y_q – value associated with quality improvement or adherence
y_s – value associated with schedule acceleration or adherence

The incentives that are offered to the shipbuilders ideally offer some percentage of the total value that these value components are supposed to add to the Navy. The incentives that the previous four contracts included fall into five basic categories:

- Shareline
- Period Awards
- Event Based Awards
- Special Incentives
- Economic Order Quantity

The total performance on all of the contracts is meant to relate directly to the total firm value that the Navy receives from the contracts. The total performance is what the Navy is able to incentivize in order to produce the value that it perceives from each of the contracts. However, there are several disconnects between what is incentivized and the value the Navy hopes to achieve.

Scale

The first issue with the incentive structures in these contracts is the scale of incentives. There is often a very large offset in the performance based on the cost component of the contract. If the shipbuilder can achieve a certain cost then they can earn a disproportional amount of the total incentive pool when compared to the quality and schedule components.

When the potential payoff achieved from the share line, which is only driven by build cost, is compared to the period and event based awards or the special incentives that each have a component of quality and schedule in their structure, the ratio of those incentives to the shareline driven by cost is largely in favor of the share line and the cost as seen in Figure 8. In other words the contractor will focus primarily on cost reductions and increases rather than on on-time delivery or quality.

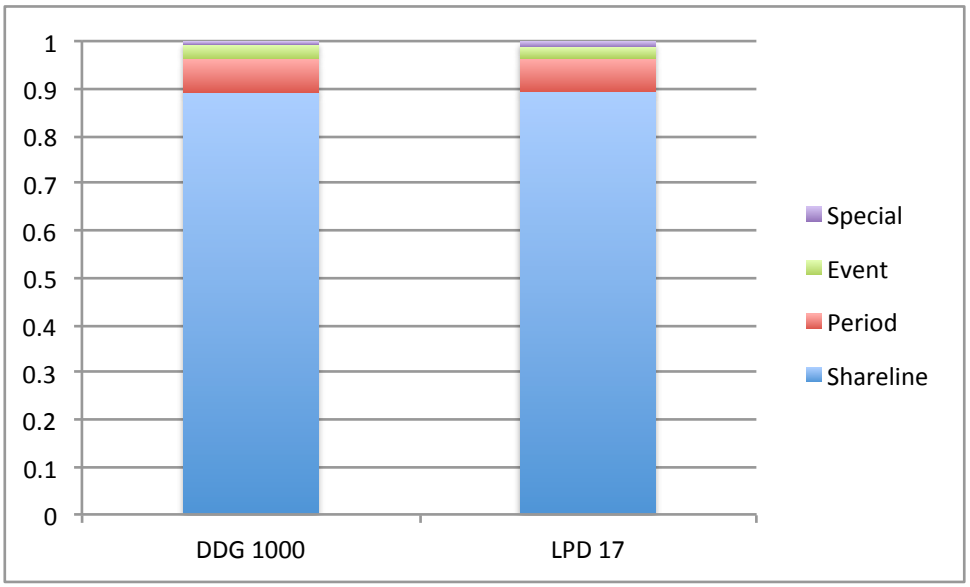

Figure 8 Incentive Type Comparison between DDG 1000 and LPD 17

Those non-share line incentives also, in a large part, contain a cost element themselves. So, the importance of the cost of the ship is even further reinforced.

The cost is so heavily incentivized that it almost doesn't make sense in most situations to have any other incentives.

The LPD 17 is an example of where the cost incentive itself failed. In the LPD 17 program, the cost escalated and arrived at a level where there was no potential incentive for it at all. The program then became more difficult to manage than it otherwise would have been if it had a larger residual incentive to shoot for at least in the cost area. The program managers found themselves in a cycle where they had to incentivize individual areas of the shipyard in piecemeal fashion and the project specifically in order to achieve the performance for which they hoped.

The obvious recommendation here is that the potential incentives be proportionally scaled to an appropriate level where they are all meaningful. This is the perfect example of the "get what you pay for" adage because if the Navy incentivizes the shipbuilders to reduce costs and nothing else then they will work to reduce those costs without focus on the other areas that the Navy values like quality and schedule performance. Neglecting quality and schedule can, however, lead to an indirect cost escalation later on. Otherwise, the resources that are allocated to the less meaningfully incentivized performance factors should be removed altogether. If the incentives used are not actually producing the desired effect then they should not be used and the resources should be reallocated.

Period Awards

Apart from other issues with the smaller incentives, the period awards have several issues especially in the LPD 17 contract. In the LPD 17 contract, there are a couple of specific items that add a level of temporal interdependence to the other incentives. The awards are allowed to be moved between periods and weighted heavily toward the later periods.

These features in the contracts allow the shipbuilder another potential for gaming the system that could act to the detriment of the Navy. If the shipbuilder's cost during a particular period associated with a period award is more during that period, then they might be tempted to push the work off toward the later period. This could created schedule delays and downstream cost escalation. The ability to regain lost incentives during later periods detracts from their intended incentive effect during the current period.

If for instance, the minimum fee that the shipbuilder could obtain in the current period was 10 if they met the very minimum performance criteria which is some subjective formulation of quality, cost, and schedule, and the very best they could do was 100, then they would try to do their very best for across those categories in order to achieve the highest payoff as in Figure 9.

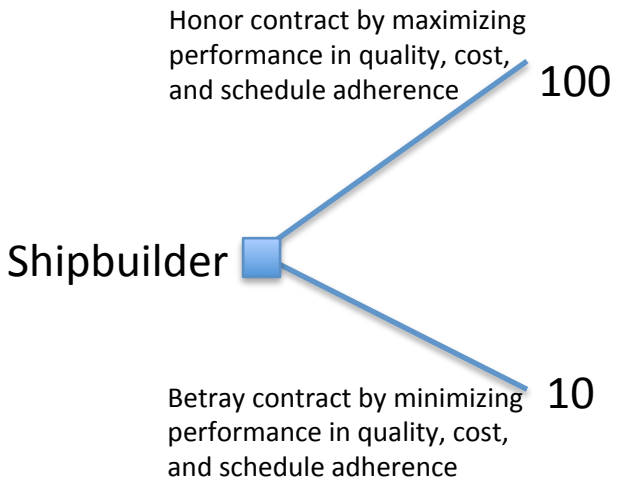

Figure 9 Simple Payoff

Now suppose that the there is an option to meet only the minimum performance criteria and still gain the additional payoff in later periods. For instance, if the cost associated with completing the task to the maximum capability is more in the earlier period than it is in the later period or the risk involved in completing it in

the earlier period is more prohibitive such as might be the case in some technology development, then the shipbuilder would be more likely to put more efforts into the later periods. In Figure 10, the risk associated with completing the task to the maximum capability is 50% and if the task is completed at less than maximum capability there is still a 50% chance that the award will be recouped in later periods. This makes the minimum performance in the current period the more attractive choice.

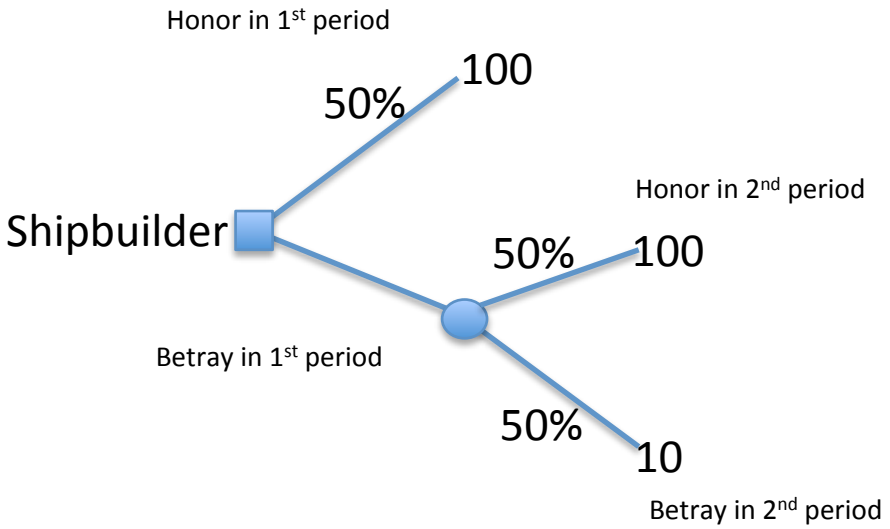

Figure 10 Potential Payoff Structure with Recouped Award in the 2nd Period

The value created by betraying the contracting in the first period is then higher than the value created by honoring the contract in the first period:

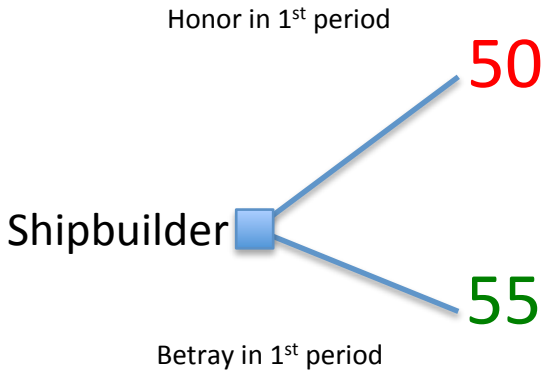

Figure 11 Value with Recouped Payoff

The consequences of such a temporal interdependence can result in an overconfidence in later periods that ultimately results in an inability to accomplish initial objectives. At worst it can result in unexpected delays and reduced quality that produces worse ships.

Because of the risk of potential consequences from the temporal interdependence components from this discussion, the recommendation here is that the temporal interdependence be broken. This could be accomplished by either removing the period awards altogether or changing the award structure to be steady throughout the ship's construction. Another conceivable approach would be to weight the early periods more heavily or increase the standards so that the risk of not receiving all of the awards in the later periods make it less attractive to delay work towards later periods.

Share Line

The share line in the traditional Fixed Price Incentive contract focuses the incentive completely on cost reduction and ideally negates all the other

incentives that are more prevalent in the Cost Plus Award Fee contracts. In the case of the VCS program, the awards are more appropriately sized so that one incentive is not competing with the other. The award fee pool devoted to the schedule and quality impacts on the program is comparable to the potential award for reducing cost. However, these were still eclipsed by the potential fee associated with the shareline incentive.

A difficulty with the share line however is its own structural misalignment. The share line incentive is based on the savings under a negotiated target cost that the shipbuilder brings to the table. The issue is that as the shipbuilder reduces the cost of the ship, they are simultaneously reducing their own profit since profit is a negotiated fixed percentage considered in the target cost of the ship. As an extreme example, consider a target cost of $190M USD in a contract where the shipbuilder would receive a minimum fee of $37M USD or a maximum fee of $75M USD based on receiving 90% of the positive difference of the actual cost subtracted from the target cost. In order to receive the maximum incentive fee, the shipbuilder would have to reduce the ship cost by $83M USD simultaneously reducing their profit. After meeting or exceeding the target cost of the ship, only the minimum incentive is available. If there were a 10% profit margin negotiated into the contract, then the shipbuilder could potentially recoup the cost in lost incentive fee by more than doubling the actual cost of the ship.

Actual Cost	Incentive Fee Awarded	Profit	Net Payoff
107M USD	75M USD	10.7M USD	85.7M USD
487M USD	37M USD	48.7M USD	85.7M USD

Table 5 Shareline Incentive Misalignment

There are some securities built into the fee structure such as an overrun responsibility of for 50% of costs above the target cost and total responsibility

above a cost ceiling, but this example is more meant to illustrate the potential for gaming the fee.

The structure of the payment incentivizes the shipbuilder to optimize to a balance between the potential profit and the potential award fee. One way to break the link that creates the gaming potential would be to not tie the profit to a percentage of the total cost and instead negotiate it as a fixed sum. Or the share line slope could be managed such that the overrun is more harshly penalized and there is no minimum fee owed to the shipbuilder. This creates more risk for the shipbuilder, but could also be more of an incentive to reduce costs.

Economic Order Quantity

However, incentivizing cost reduction too heavily returns the possibility that the other performance characteristics of quality and schedule are neglected. This is where increasing order quantity plays a more important role. Block buys and multi year procurements are all ways that the Navy can incentivize continuous performance in all aspects that create value in a shipbuilding program. First of all, it reduces the marginal cost of each ship as the overhead costs are amortized over a longer period of time and over a larger number of ships. It is then a much larger incentive than what could be accomplished by an individual ship contract that it motivates the shipbuilder to not lose the contract by performing in every instance at their best. The profit on a several billion-dollar program far outweighs the potential incentive fees for an individual program. A greater incentive produces more leverage for the Navy and a greater motivation for the shipbuilder to improve over time. It is also a larger potential risk for the shipbuilder since if it were to perform poorly on the first ship then it could lose even more money because of the overhead investment and opportunity cost in anticipation of the larger buy. That risk would have to be accounted for in a larger profit margin for instance.

The LCS program was able to leverage the use of a block buy in order to purchase ten ships from two different shipbuilders. The program was kept under its target cost using the fixed price contract with only a well designed share line incentive and was completed well within its projected timeframe. There were several quality issues with the first ship of the class, but overall the program has been considered a success. The large number of ships at stake for the entire award was an extremely valuable incentive, but after discussing it with relevant sources within the program, competition was also a valuable resource in the negotiations with and performance of the shipbuilders.

Chapter 7 Competitive Base

As previously discussed, there is no true competitive industrial base left within the U.S. shipbuilding industry. As a result of the lack of competition, there is no true free market operating within the industry. There are two major shipbuilders that control the majority of the revenue within the entire industry (see Figure 1). This gives them a major advantage in negotiations and because their capabilities are so important, there is less effective incentive for them to produce ships as efficiently as possible. These large shipbuilders are going to receive large payoffs and large amounts of work no matter how they perform and they know it.

One solution would be to treat the entire industry as a free market failure and nationalize shipbuilding altogether. There are several difficulties with this proposition as seen in other countries. First off, it sends a signal to other industries that the government could potentially bail them out if they were run poorly and were relevant enough to the economy. Additionally, it sends the signal to foreign investors that there is a larger risk in their investments because they could have to compete with the government directly in certain industries if further nationalization were to occur. This would result in an overall reduction in foreign direct investment and ultimately a potential shrinkage in the US economy. This is a potential knock-on effect from shipbuilding to other parts of the U.S. manufacturing sector. Based on the market capitalization of HII and GD full nationalization would cost around $15B USD. Even with a long-term reduction in overall cost of shipbuilding contracts owing to a greater incentive for increased efficiency, the risks associated could make this number difficult to justify as an initial capital injection.

There are several examples where industries have had similar issues with a very small competitive base and have worked to increase the competition amongst different suppliers instead of purchasing those suppliers. The electronics industry can have these issues when there are very advanced parts that only few

suppliers can produce due to the complexity of the parts and the supplier's large manufacturing capability. To increase the supplier base, the buyer uses strategic contracting or even direct investment in smaller companies to build their capability and push those advanced parts to become more like commodities where the competition will produce the best value. The strategic contracting is often done using a stable long-term project where there will not be as much of a learning curve or associated risks for the new company. Portions of the project are allocated to the newer and often smaller company, which gives them a more stable projection of future earnings that they can use to increase their leverage for investing in themselves to increase their capabilities. The new company then has the capability to compete with the larger more experienced companies increasing the competitive base and the value that the buyer receives from the purchase of the product.

An example of this sort of investment in the government sector is the case of In-Q-Tel. In-Q-Tel (IQT) was founded in 1999 to "acquire greater access to cutting-edge technologies for the US Central Intelligence Agency"[39] It's a private, non-profit that receives most of its funding from the federal intelligence budget. IQT acts as the same way that a venture capital fund works. IQT scouts out cutting-edge technologies that could potentially benefit the CIA. IQT then provides the money that a technology company would need in order to adapt and deploy the technology to the intelligence community through a direct investment for equity and then through large purchses of the selected technology. With the CIA as a definite customer and IQT supporting the company with its investments, the company can then gain additional support and money from other firms and acquire additional customers through leverage. IQT's annual budget in 2006 was approximately $50M USD.[40] IQT uses that budget in order to make individual investments on the order of $1-3M USD in order to receive an equity position in

[39] Book, K., Hardymon, F., Leamon, A., Lerner, J. "In-Q-Tel", Harvard Business School, 25 May 2005.
[40] Firmansyah, T., Kantrowitz, A., London, R., Mashhadi, O., Riggins, M. "In-Q-Tel as an Early Stage Investment Model", Chesapeake Crescent, accessed April 2013.

the company. This would allow the company to potentially become self-funding through its equity investments and exits while prioritizing the issues that the CIA needs resolved most in the investments. This allows the CIA to align the priorities of the company and the industry with their own. In order to work with smaller companies without the more cumbersome Federal Acquisition Regulations (FARs), the CIA adopted a DARPA-based exemption on "Other Transactions (OT)" granted to the DOD by Congress which permits R&D agreements outside of the FARs.[41]

The Navy might use similar models as the electronics industry and the CIA in order to create a more competitive base in the shipbuilding industry. Currently, the Navy allows for a Capital Expenditure provision in its contracts that allows shipbuilders to add a certain percentage into the allowable costs in the contract to invest in their own capabilities. This can increase the capabilities of the shipbuilder and potentially improve the efficiency of the ship's construction. The capital expenditure provision was used successfully in both the VCS and LCS programs and also provided that Austal would provide from its own capital in order to increase its capability.

Austal was an example where a foreign shipyard teamed with a smaller tier 2 shipyard in order to increase its capability and compete with the larger tier 1 shipyards for the LCS contract. Rather than just using a capital expenditure incentive in contracts, the Navy could invest in a company that would act solely in the interest of the Navy using a smaller shipyard as a base and building up its capability to be able to compete with the larger shipyards for a portion of the more complex ship projects. The Navy would therefore be able to better control the processes of that new shipbuilder as a major stockholder and potentially use an equity position in order to self-fund projects. The new shipbuilder would also provide an increased leverage position for negotiations with the larger

[41] Yannuzzi, R.,"In-Q-Tel: A New Partnership Between the CIA and the Private Sector", https://www.cia.gov/library/publications/additional-publications/in-q-tel/index.html. Accessed April 2013.

shipbuilders and push their interests more closely in line with those of the Navy requiring an increase in quality, cost reduction, and schedule adherence.

A low risk vehicle for the Navy to begin this process is the search fund model. A search fund allows "an aspiring entrepreneur the opportunity to search for, acquire, manage, and grow a company."[42] In the search fund model, the entrepreneur locates 10-15 investors of around $30k USD in order to fund a search for the most appropriate company for acquisition. These companies are generally valued around $15M USD with established revenue of $4-5M USD per year. The entrepreneur meets with several companies over 1-2 years and presents them back to the original investors in the search fund for review and approval. Those investors get the right to first refusal of whether they want to provide the necessary capital for the acquisition. The investors provide somewhere on the order of 60% of the necessary capital for the purchase and the rest is either leveraged through a bank or through some type of seller financing. The entrepreneur then maintains about 20% equity in the company and remains in place as the CEO of the company with a focus on growing the company out and increasing the value of the company over an average of 5-7 years. At that point, the company is usually sold. As of 2009, search funds as an asset class produced a 37% IRR and 13.5x multiple on investments. However, while these returns are significant, there are also 59% of search funds that have produced at least a partial loss of capital.[43]

From the Navy's perspective, utilizing a model like this could potentially excite more entrepreneurial investment in the shipbuilding industry. If the Navy were to participate in a search fund, other investors would invariably be attracted to the prospect and add capital. The model is a low initial investment for the Navy with potential for an equity stake in a growing shipbuilder. This could create a stable competitor without going towards full nationalization of U.S. shipyards. Through

[42] "A Primer on Search Funds: A Practical Guide to Entrepreneurs Embarking on a Search Fund", Board of Trustees of the Leland Stanford Junior University, 2010.
[43] IBID.

the use of strategic contracts and production sharing with the smaller company purchased through the model, the smaller tier 2 shipbuilder purchased could eventually become a competitor with the larger shipbuilders while exciting the entrepreneurial community toward the shipbuilding industry and building an even larger competitive base in the industry.

Taking equity stake in any company would require either a change to the FARs or the use of a similar outside agency as IQT. While this could be difficult, the upside is large. With a relatively small initial investment and low risk of failure, the Navy could increase competition in the shipbuilding industry and better align the interests of the shipbuilding industry more closely with the Navy's.

Chapter 8 Conclusions and Recommendations

This research thesis analyzed four current Navy contracts and their incentive structures as a way to increase competition and productivity in the U.S. military shipbuilding industry which is currently dominated by 70% sole source contracts. The analysis was done with incentives outside of monetary payoff in mind, but also a look at the scale and alignment of the monetary payoffs with the intended performances. The recommendations given for each of the incentive types provided potential solutions to the misalignment of those incentives with the outcome for which the U.S. Navy hoped. However, those recommendations would potentially provide only a marginal improvement to the efficiency of shipbuilding contracts by way of an improvement in cost reduction, quality, and schedule adherence. Larger improvement would require a larger change in the contracting process and the industry as a whole. This change is possible through investment into the competitive base of the industry, which could potentially take the form of a search fund initially as a vehicle to grow a tier 2 shipbuilder into a tier 1 competitor.

Specific recommendations are as follows:

1. The Navy should invest in a search fund to take an equity stake in several tier 2 shipbuilders that can eventually be used to compete with tier 1 shipbuilders and increase the competitive industrial base in shipbuilding. The initial investment is low enough to mitigate risk at least at the outset and allow for multiple tier 2 shipbuilders to be vetted thoroughly for larger investments.

2. The search fund would be capitalized as an allocation through the Navy's shipbuilding budget or as a portion of SIBIF, but maintained as a separately

operating entity in order to be entitled to equity portions of the companies in which it was invested in order to eventually become self sufficient.

3. When operating without the ability to increase the competitive base, Navy contracts need to focus on the actual allocation of incentives. The Navy has already moved away from the use of Cost Plus Award fee type contracts and the current trend is to contract using the Fixed Price Incentive Contract type. This type of contracting has allowed for the consolidation of smaller incentives that might be easier to misalign when very subjective performance metrics are used to measure their allocation and might be made irrelevant depending on the relative scale of the incentives when compared to each other. Shipbuilders rationally act based on their potential payoffs. The larger potential payoff for creating a value to the Navy, the more important creating that value is to the shipbuilder.

4. The Fixed Price Incentive contract promises a much larger potential payoff then the smaller awards that might otherwise be possible. Consolidating those awards in to just one large incentive for overall cost reduction and reducing it at some percent based on missing concurrent and measurable quality and schedule targets is a step toward offering a very large payoff. However, the largest potential payoff for the shipbuilder comes from the longevity of a larger volume program.

5. The larger the program, the more costs can be amortized across multiple ships through economies of scale. It also provides a long and stable revenue source for the shipbuilder which increases the attractiveness of further internal investment. An extension, therefore, to the larger payoffs created by the Fixed Price Incentive contracts would be to create even larger payoffs by removing monetary incentives for individual ships and focusing those fund on more ships to be constructed overall. This would require a large commitment on the part of the Navy and the government to use those funds that it would have allocated as

incentive directly for additional procurements. It also creates more periods for the interactions of the Navy and the shipbuilder in which it would be more detrimental for the shipbuilder not to make every effort possible to produce the value the Navy is seeking (i.e. avoid defections from existing contract terms). It gives the shipbuilders room to be creative in their own creation of ways to reduce costs while maintaining quality and schedule adherence.

6. The lack of an incentive payment plan has the potential to produce cash flow issues for the shipbuilder especially when they are considering capital investments themselves for increased production efficiency. For this reason, a capital investment provision should be maintained within the contracts, not as a standalone incentive, but as an aid when the company would not otherwise be able to invest in its own capacity.

Future work in this area includes the following research items:

- Expansion of the number of programs and contracts analyzed beyond the four case studies in this thesis.
- Implementation of a software program for optimal shipbuilding contract design based on the two major contract types and five interlinked contract types identified here.
- Correlation of the manufacturing ecosystem recommendations of the overall PIE study with the specific recommendations for strengthening the tier 1 and tier 2 industrial base in US shipbuilding
- Development of a pre- and post-contract negotiations game that could include between two and six stakeholders as both a training tool as well as a way to identify potential improvements of future US shipbuilding contracts
- Analysis of the potential for US commercial shipbuilding to expand due to the enlargement of the Panama canal and the potential for a U.S. marine

highway for coast-to-coast cargo shipping and ensuing positive spillover effects from increased domestic commercial shipbuilding.

- Cost to benefit analysis of full nationalization of the shipbuilding industry in the US

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Appendix

Program Questions

DDG 1000

1. What are the standards by which you judge a program to be successful?
2. How does the DDG 1000 measure by that model?
3. Is changing the procurement schedule by stretching or decreasing the number of ships the single biggest contributor to contract performance?
    a. What other contractual features have the biggest impacts on success?
4. How are those drivers controlled within the contract for the DDG 1000?
5. What are the limits for incentives for a particular contract? Is there a basic formula used?
    a. How would you structure the incentives differently if given the opportunity?
6. How did you judge the Cost Plus v. Fixed Price Incentive contract to be the best fit for the DDG 1000?
    a. Would you have gone with the same contract type knowing what you know now?
    b. Can you affect those incentives once the contract has been signed?
7. Does the formal change process vary for the DDG 1000 from other programs?
    a. Do you use incentives in change orders?
    b. Are there acquisition requirements that limit how incentives might be implemented on those?
8. Program Manager tour length is 4yrs. Should that be longer or shorter?
    a. Is continuity to the leadership an important factor for program success?
9. What are major affects of shipyards running at capacity?
    a. Does a shipyard operating at lower than optimal capacity contribute positively to the construction of a ship or does the government lose on the associated overhead costs?
10. Should government terminate contracts for poor performance?
    a. What should be done to contractors who are under performing?
    b. Are there DoD regulations that prevent us from incentivizing better performance or penalizing poor performance?
11. How are inefficiencies in the supply chain managed within the DDG 1000 program?
    a. For GFE?
    b. For Prime Contractors?

Ultimately, are there limitations that we are placing on ourselves that prevent us from improving our contracting processes?

Littoral Combat Ship (LCS)

1. What are the standards by which you judge a program to be successful?
2. How does the Littoral Combat Ship (LCS) measure by that model?
3. Is changing the procurement schedule by stretching or decreasing the number of ships the single biggest contributor to contract performance?
    a. What other contractual features have the biggest impacts on success?
4. How are those drivers controlled within the contract for the LCS?
5. What are the limits for incentives for a particular contract? Is there a basic formula used?
    a. How would you structure the incentives differently if given the opportunity?
6. How did you judge the Fixed Price Incentive v. Cost Plus contract to be the best fit for the LCS?
    a. Would you have gone with the same contract type knowing what you know now?
    b. Can you affect those incentives once the contract has been signed?
    c. On what factors was the Dual Award v. Downselect bidding process chosen?
7. Does the formal change process vary for the LCS from other programs?
    a. Do you use incentives in change orders?
    b. Are there acquisition requirements that limit how incentives might be implemented on those?
8. Program Manager tour length is 4yrs. Should that be longer or shorter?
    a. Is continuity to the leadership an important factor for program success?
9. What are major affects of shipyards running at capacity?
    a. Does a shipyard operating at lower than optimal capacity contribute positively to the construction of a ship or does the government lose on the associated overhead costs?
10. Should government terminate contracts for poor performance?
    a. What should be done to contractors who are under performing?
    b. Are there DoD regulations that prevent us from incentivizing better performance or penalizing poor performance?
11. How are inefficiencies in the supply chain managed within the LCS program?
    a. For GFE?
    b. For Prime Contractors?
12. Ultimately, are there limitations that we are placing on ourselves that prevent us from improving our contracting processes?

LPD 17

1. What are the standards by which you judge a program to be successful?
2. How does the LPD 17 measure by that model?
3. Is changing the procurement schedule by stretching or decreasing the number of ships the single biggest contributor to contract performance?
    a. What other contractual features have the biggest impacts on success?
4. How are those drivers controlled within the contract for the LPD 17?
5. How did you judge the Cost Plus v. Fixed Price Incentive contract to be the best fit for the LPD 17?
    a. Would you have gone with the same contract type knowing what you know now?
6. What are the limits for incentives for a particular contract? Is there a basic formula used?
    a. How would you structure the incentives differently if given the opportunity?
    b. Can you affect those incentives once the contract has been signed?
7. Does the formal change process vary for the LPD 17 from other programs?
    a. Do you use incentives in change orders?
    b. Are there acquisition requirements that limit how incentives might be implemented on those?
8. Program Manager tour length is 4yrs. Should that be longer or shorter?
    a. Is continuity to the leadership an important factor for program success?
9. What are major affects of shipyards running at capacity?
    a. Does a shipyard operating at lower than optimal capacity contribute positively to the construction of a ship or does the government lose on the associated overhead costs?
10. Should government terminate contracts for poor performance?
    a. What should be done to contractors who are under performing?
    b. Are there DoD regulations that prevent us from incentivizing better performance or penalizing poor performance?
11. How are inefficiencies in the supply chain managed within the LPD 17 program?
    a. For GFE?
    b. For Prime Contractors?
12. Ultimately, are there limitations that we are placing on ourselves that prevent us from improving our contracting processes?

Virginia Class Submarine (VCS)

1. What are the standards by which you judge a program to be successful?
2. How does the Virginia Class Submarine (VCS) measure by that model?
3. Is changing the procurement schedule by stretching or decreasing the number of ships the single biggest contributor to contract performance?
    a. What other contractual features have the biggest impacts on success?
4. How are those drivers controlled within the contract for the VCS?
5. What are the limits for incentives for a particular contract? Is there a basic formula used?
    a. How would you structure the incentives differently if given the opportunity?
6. How did you judge the Cost Plus v. Fixed Price Incentive contract to be the best fit for the VCS?
    a. Would you have gone with the same contract type knowing what you know now?
    b. Can you affect those incentives once the contract has been signed?
7. Does the formal change process vary for the VCS from other programs?
    a. Do you use incentives in change orders?
    b. Are there acquisition requirements that limit how incentives might be implemented on those?
8. Program Manager tour length is 4yrs. Should that be longer or shorter?
    a. Is continuity to the leadership an important factor for program success?
9. What are major affects of shipyards running at capacity?
    a. Does a shipyard operating at lower than optimal capacity contribute positively to the construction of a ship or does the government lose on the associated overhead costs?
10. Should government terminate contracts for poor performance?
    a. What should be done to contractors who are under performing?
    b. Are there DoD regulations that prevent us from incentivizing better performance or penalizing poor performance?
11. How are inefficiencies in the supply chain managed within the VCS program?
    a. For GFE?
    b. For Prime Contractors?
12. Were there any major inefficiencies identified by the VCS cost reduction effort?
    a. Are there limits to how those cost reduction efforts can be incentivized and implemented?
13. What positive effects did the CAPEX program have on the acquisition of the VCS?
14. Ultimately, are there limitations that we are placing on ourselves that prevent us from improving our contracting processes?

Deputy Assistant Secretary of the Navy (DASN) (Acquisition and Procurement)

I. Cost Cutting Incentives

1. What sorts of assurances are in place to ensure that a company doesn't take full advantage of their cost reduction measures to increase their own profit without reducing the Navy price? Other than:
    a. Changing share line
    b. Full cost transparency
    c. Is there full cost transparency?
2. What incentivizes a company to reduce cost even though they are not only putting in the effort on the front end of this contract, but will also affect future bids by analogy?
3. Could a steady focus on designing the ship completely before building ever be achieved?
    a. How would that reduce total ownership costs v. acquisition?
4. How discretionary are the cost cutting measurements?
    a. Could there potentially be less of a fixed formula for those measurements?
    b. What might that look like?

II. Potential Innovation

5. What sorts of incentives exist beyond a budget for R&D to promote innovation within the shipyards?
6. Do you think that more competition between shipyards is the right answer to produce the most cost effective solution, or could a consolidation across the board and a single shipyard put more pressure on the industry to provide cost effective solutions?
    a. A free market is the most efficient for industries, but is the illusion of a free market in this industry creating higher overall and especially transaction costs?
7. What drawbacks have you seen in block buys from contracts?
    a. Can economies of scale potentially limit innovation?

III. Standardization and Shipyard Refinement

8. Why do companies increase their leverage and spend the additional funds necessary to improve their facilities?
    a. Are there any practices in place or in the near future to incentivize such behavior?
9. Does a separation of maintenance and construction make sense?
    a. Could this establish more standardization of components and fewer issues with replacement?